The University of Minnesota Bulletin

School of Mines

MINNEAPOLIS, MINN.

The University of Minnesota Bulletin

School of Mines

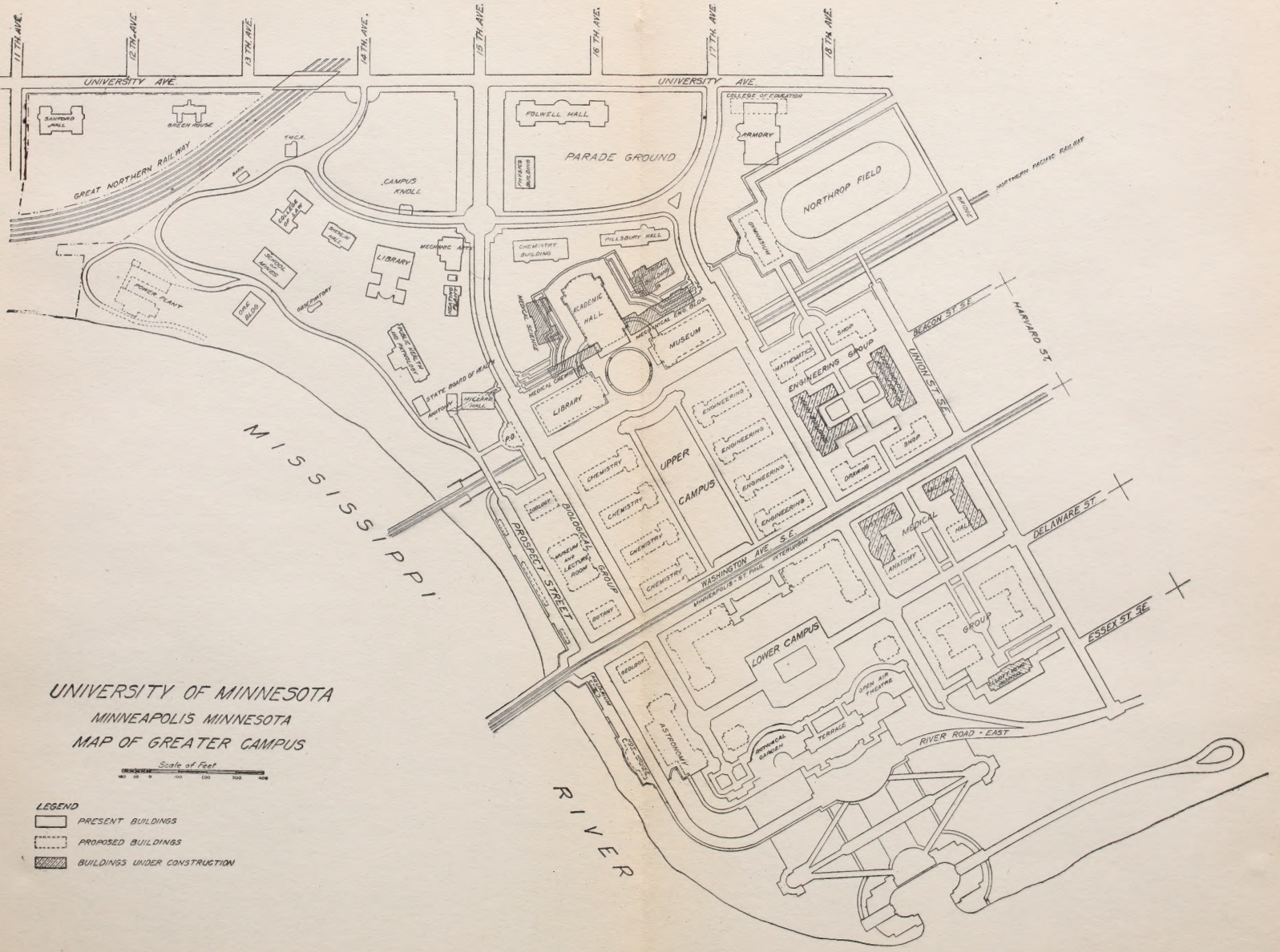
1911-1912

Volume XIV May 1911 No. 6

Entered at the Postoffice
in Minneapolis as second-class matter
MINNEAPOLIS, MINN.

The University catalogues are published by authority of the Board of Regents, as a regular series of bulletins. One bulletin for each college and one for the summer session is published every year and in addition a bulletin of general information outlining the entrance requirements of all colleges of the University, and embodying such items as University equipment, organizations and publications, expenses of students, loan and trust funds, scholarships, prizes, etc. Bulletins will be sent gratuitously, postage paid, to all persons who apply for them. In calling for bulletins, the college or school of the University concerning which information is desired should be stated. Address,

THE REGISTRAR,
The University of Minnesota,
Minneapolis, Minnesota.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Y.M.C.A.
CAMPUS KNOLL
FOLWELL HALL
PARADE GROUND
COLLEGE OF EDUCATION
ARMORY
NORTHROP FIELD
NORTHERN PACIFIC RAILWAY
GYMNASIUM
CHEMISTRY BUILDING
PILLSBURY HALL
ACADEMIC HALL
MECHANICAL ENG. BLDG.
MUSEUM
MECHANIC ARTS
LIBRARY
POWER PLANT
SCHOOL OF MINES
PHYSICS BLDG.
GREENHOUSE
GYMNASIUM
ROSE CONSERVATORY
PUBLIC HEALTH LABORATORIES
STATE BOARD OF HEALTH
ANATOMY
MILLARD HALL
MEDICAL SCIENCE
LIBRARY
P.O.
MATHEMATICS
ENGINEERING GROUP
SHOP
DRAWING
BEACON ST. S.E.
HARVARD ST.
UNION ST. S.E.
MISSISSIPPI
RIVER
UPPER CAMPUS
CHEMISTRY
ENGINEERING
BIOLOGICAL GROUP
MUSEUM AND LECTURE ROOM
BOTANY
PROSPECT STREET
WASHINGTON AVE. S.E.
MINNEAPOLIS - ST. PAUL INTERURBAN
MEDICAL GROUP
ANATOMY
DELAWARE ST.
ESSEX ST. S.E.
LOWER CAMPUS
GEOLOGY
ASTRONOMY
OPEN AIR THEATRE
TERRACE
BOTANICAL GARDEN
RIVER ROAD - EAST
UNIVERSITY OF MINNESOTA
MINNEAPOLIS MINNESOTA
MAP OF GREATER CAMPUS
Scale of Feet
LEGEND
PRESENT BUILDINGS
PROPOSED BUILDINGS
BUILDINGS UNDER CONSTRUCTION

CALENDAR FOR 1911-1912

1911

JULY

S.	M.	T.	W.	T.	F.	S.
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2	3	4	5	6	7	8
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23	24	25	26	27	28	29
30	31	..	..	..	..	..

AUGUST

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SEPTEMBER

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24	25	26	27	28	29	30
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OCTOBER

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NOVEMBER

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DECEMBER

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31	..	..	..	..	..	..

1912

JANUARY

S.	M.	T.	W.	T.	F.	S.
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FEBRUARY

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MARCH

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31	..	..	..	..	..	..

APRIL

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MAY

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JUNE

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30	..	..	..	..	..	..

University Calendar

1911-1912

THE UNIVERSITY YEAR

The University year covers a period of thirty-eight weeks, beginning on the second Tuesday in September. Commencement Day is always the second Thursday in June.

1911			
September	5	Tuesday	Registration closes except for new students
Sept.	5-12	Week	Fees payable except for new students
Sept.	12-18	Week	Entrance examinations, freshman registration and payment of fees
Sept.	13-19	Week	Military encampment of cadets
September	20	Wednesday	First semester begins
September	26	Monday	University Council meeting
October	2	Monday	School of Agriculture session begins
October	5	Thursday	Board of Regents meeting
November	29	Wednesday	Thanksgiving recess begins 5:40 P. M.
December	4	Monday	Thanksgiving recess ends 8:30 A. M.
December	4	Monday	University Council meeting
December	12	Tuesday	Board of Regents meeting
December	22	Friday	Christmas vacation begins 5:40 P. M.
1912			
January	9	Tuesday	Christmas vacation ends 8:30 A. M.
January	23	Tuesday	Registration for second semester closes
January	29	Monday	Final examinations begin
January	30	Tuesday	Payment of fees for second semester closes
February	7	Wednesday	Second semester begins
February	12	Monday	Lincoln's Birthday: holiday
February	17	Saturday	First semester class reports due
February	22	Thursday	Washington's Birthday: holiday
March	20	Wednesday	School of Agriculture closes
March	30	Saturday	Easter recess begins 5:40 P. M.
April	8	Monday	Easter recess ends 8:30 A. M.
April	22	Monday	University Council meeting
May	2	Thursday	Board of Regents meeting

May	23	Thursday	Final examinations begin
May	30	Thursday	Decoration Day; holiday
June	8	Saturday	Second semester closes
June	9	Sunday	Baccalaureate service
June	10	Monday	Senior class day exercises
June	11	Tuesday	Phi Beta Kappa address
June	12	Wednesday	Alumni Day
June	13	Thursday	Fortieth Annual Commencement
June	14	Friday	Summer vacation begins

The University year for 1912-13 will begin Monday, September 10

Program of Entrance Examinations

1911-12

When entrance examinations are required this schedule will be followed:

June	1	Thursday	9 A. M.	Elementary and Higher Algebra
June	2	Friday	9 A. M.	Plane and Solid Geometry
September	12	Tuesday	9 A. M.	Astronomy
				Botany
				Geology
				Chemistry
				Physiography
				Zoology
			2 P. M.	American Government
				History
				Economics
				Physics
				Commercial Geography
September	13	Wednesday	9 A. M.	English
			2 P. M.	German
				French
				Latin
				Scandinavian
September	14	Thursday	9 A. M.	Elementary Algebra
			2 P. M.	Higher Algebra
September	15	Friday	9 A. M.	Plane Geometry
			2 P. M.	Solid Geometry

All candidates for examinations should report at the scheduled time in Room 205, Library Building, except in the case of mathematics.

Examinations in mathematics are held in Room 24, School of Mines Building.

Program—Supplementary Examinations

Sept.	12	Tuesday	2-5	Mining Engineering Subjects
Sept.	13	Wednesday	9-12	Chemistry
Sept.	13	Wednesday	2-5	Drawing and Descriptive Geometry Mechanical Engineering Subjects
Sept.	14	Thursday	9-12	Metallurgical Subjects Physics
Sept.	15	Friday	9-12	Electrical Engineering Subjects
			2-5	Geology and Mineralogy

The University

The University of Minnesota comprises the following named schools colleges, and departments:

The College of Science, Literature, and the Arts

The College of Engineering and the Mechanic Arts

The Department of Agriculture, including—

- The College of Agriculture
- The College of Forestry
- The School of Agriculture
- The Dairy School
- The Short Course for Farmers
- The Short Course for Teachers
- The School of Traction Engineering
- The School of Agriculture, Crookston
- The School of Agriculture, Morris
- The Experiment Stations, including—
  - The Main Station at St. Anthony Park
  - The Sub-Station at Crookston
  - The Sub-Station at Grand Rapids

The College of Law

The College of Medicine and Surgery, including—

- The Training School for Nurses

The College of Dentistry

The College of Pharmacy

The School of Mines

The School of Analytical and Applied Chemistry

The College of Education

The Graduate School

The Geological and Natural History Survey

Bulletins of these schools, colleges, and departments may be obtained upon application to the University Registrar.

The Board of Regents

The HON. JOHN LIND, MINNEAPOLIS 1914
The President of the Board

GEORGE EDGAR VINCENT, Ph. D., LL. D., MINNEAPOLIS *Ex-Officio*
The President of the University

The HON. ADOLPH O. EBERHART, MANKATO . *Ex-Officio*
The Governor of the State

The HON. C. G. SCHULZ, ST. PAUL . . . *Ex-Officio*
The State Superintendent of Public Instruction

The HON. W. J. MAYO, ROCHESTER 1913

The HON. MILTON M. WILLIAMS, LITTLE FALLS . . 1913

The HON. HENRY B. HOVLAND, DULUTH 1914

The HON. A. E. RICE, WILLMAR 1915

The HON. CHARLES L. SOMMERS, ST. PAUL . . . 1915

The HON. B. F. NELSON, MINNEAPOLIS 1916

The HON. PIERCE BUTLER, ST. PAUL 1916

The HON. CHARLES A. SMITH, MINNEAPOLIS . . . 1916

C. D. DECKER, MINNEAPOLIS,
Secretary of the Board.

Executive Officers

THE UNIVERSITY

GEORGE EDGAR VINCENT, Ph. D., LL. D., President

ERNEST B. PIERCE, B. A., Registrar

JAMES T. GEROULD, B. A., Librarian

CALVIN D. DECKER, Purchasing Agent

JOSEPH D. BREN, Treasurer

THE COLLEGES

JOHN F. DOWNEY, M. A., C. E., Dean of the College of Science, Literature, and the Arts

FRANCIS C. SHENEHON, C. E., Dean of the College of Engineering and the Mechanic Arts

ALBERT F. WOODS, M. A., Dean and Director of the Department of Agriculture

*WILLIAM S. PATTEE, LL. D., Dean of the College of Law

FRANK FAIRCHILD WESBROOK, M. A., M. D., C. M., Dean of the College of Medicine and Surgery

ALFRED OWRE, B. A., M. D., C. M., D. M. D., Dean of the College of Dentistry

FREDERICK J. WULLING, Phm. D., LL. M., Dean of the College of Pharmacy

WILLIAM R. APPLEBY, M. A., Dean of the School of Mines

GEORGE B. FRANKFORTER, M. A., Ph. D., Dean of the School of Chemistry

GEORGE F. JAMES, Ph. D., Dean of the College of Education

HENRY T. EDDY, C. E., Ph. D., LL. D., Dean of the Graduate School

ADA L. COMSTOCK, M. A., Dean of Women

*Died April 4, 1911.

The University Council

At the regular meeting of the Board of Regents of the University May 31, 1905, a University Council was established according to the following plan:

I. The name of the body shall be the University Council. It shall consist of the President of the University, the Deans of the various colleges and schools, one elected representative from each college or school for each 400 students or major fraction thereof, and one representative of the General Alumni Association.

II. The elected members shall serve for a period of one year. They shall be chosen from the various faculties at the time of the selection of standing committees. The representative of the General Alumni Association shall be chosen by that body at its annual meeting from among the alumni who are not members of the University.

III. The Council shall be authorized to—

a) Appoint the following committees or the faculty representation thereon:

The University auditing committee
The University press committee
The committee on athletics
The committee on University relations to other institutions of higher learning
The committee on health and sanitation
The committee on commencement and other University functions
The committee on catalogue, programs and courses of study
The committee on student entertainments and social affairs
And such other committees as the general University interests may require

b) Receive reports from such committees and to make such recommendations as may be required.

c) Consider and act upon any matter of general University interest beyond the province of a single faculty which may be referred to it by the President of the University or any Faculty.

IV. The Council shall hold stated meetings upon the first Monday of October, December, April, and June, and such other meetings as the President of the University may call.

Representatives to the Council

The University

George Edgar Vincent, President

The College of Science, Literature, and the Arts

Dean John F. Downey — Professor H. F. Nachtrieb
Professor J. C. Hutchinson — Professor Carl Schlenker
Professor Norman Wilde

The College of Engineering and the Mechanic Arts

Dean Francis C. Shenehon — Professor George D. Shepardson

The College and School of Agriculture

Dean Albert F. Woods — Professor John T. Stewart
Professor Edward M. Freeman

The College of Law

Acting Dean Adam C. Hickman — Professor Henry J. Fletcher

The College of Medicine and Surgery

Dean F. F. Wesbrook — Professor Thomas G. Lee

The College of Dentistry

Dean Alfred Owre — Professor Richard Olding Beard

The College of Pharmacy

Dean Frederick John Wulling

The School of Mines

Dean William R. Appleby

The School of Chemistry

Dean George B. Frankforter

The College of Education

Dean George F. James

The Graduate School

Dean Henry T. Eddy

The Dean of Women

Ada L. Comstock

The University Library

James T. Gerould

The General Alumni Association

David P. Jones

University Council Committees

The University Auditing Committee

Professors Sigerfoos, Fletcher, Mitchell, Stewart

The Committee on Athletics

Professors Paige, Harding, D. P. Jones, Litzenberg, Robinson

The Committee on Grounds and Sanitation

Professors Wesbrook, Bass, Shenehon, Flather, Frankforter, Woods, Clements

The Press Committee

Professors Thomas, Beach, John Zeleny, Bauer, Miner

The Committee on Commencement and other University Functions

Professors Nachtrieb, Butts, James, Schlenker, Dr. Scott, Wilde, Washburn, Owre, Scott

The Committee on Student Entertainments and Social Affairs

Professors Pike, Comstock, Cooke, Butts, Sidener, Freeman, Ford

The Committee on University Relations to other Institutions of Higher Learning

Professors Downey, Bothne, Eddy, James, Lee, Appleby, Woods, Shepardson, Hutchinson

The Committee on University Extension and University Lectures

Professors James, Gray, Haecker, Jenks, Wulling, Burton, Johnston

The Committee on the Library

Professors Eddy, Fletcher, Gerould, Reynolds, Shenehon, Van Barneveld, White, Craig, Mullin

The School of Mines

FACULTY

CYRUS NORTHROP, LL. D., President Emeritus

GEORGE EDGAR VINCENT, Ph. D., LL. D., President
WILLIAM R. APPLEBY, M. A., Dean and Professor of Metallurgy
CHARLES E. VAN BARNEVELD, B. A., Sc., E. M., Professor of Mining Engineering
CHARLES W. BENTON, Litt. D., Professor of Romance Languages
PETER CHRISTIANSON, B. S., E. M., Professor of Metallurgy
ELTING H. COMSTOCK, M. S., Professor of Mechanics and Mathematics
JOHN J. FLATHER, Ph. B., M. E., Professor of Mechanical Engineering
GEORGE B. FRANKFORTER, Ph. D., Professor of Chemistry
CHRISTOPHER W. HALL, M. A., Professor of Mineralogy and Geology
WILLIAM H. KAVANAUGH, M. E., Professor of Experimental Engineering
WILLIAM H. KIRCHNER, B. S., Professor of Drawing and Descriptive Geometry
EDWARD P. MCCARTY, E. M., Professor of Mining
JOHN G. MOORE, B. A., Professor of German
LEVI B. PEASE, M. S., Professor of Metallurgy
GEORGE D. SHEPARDSON, M. A., M. E., Professor of Electrical Engineering
CHARLES F. SIDENER, B. S., Professor of Chemistry
JOSEPH M. THOMAS, Ph. D., Professor of Rhetoric
JOHN ZELENY, Ph. D., Professor of Physics
FRANK F. GROUT, M. S., Assistant Professor of Mineralogy and Geology
MERTON S. KINGSTON, E. M., Assistant Professor of Mining
EDWIN M. LAMBERT, M. E., Assistant Professor of Mechanics and Mathematics
WILLIAM T. RYAN, E. E., Assistant Professor of Electrical Engineering
S. CARL SHIPLEY, B. S., M. E., Assistant Professor of Machine Construction
CHARLES F. SHOOP, B. S., Assistant Professor of Experimental Engineering

INSTRUCTORS AND ASSISTANTS

Oliver Bowles, M. A., Instructor in Mineralogy and Geology
Lillian Cohen, M. S., Instructor in Chemistry
Francis C. Frary, M. S., Instructor in Chemistry
Robert W. French, B. S., Instructor in Drawing
William F. Holman, Ph. D., Instructor in Physics
Louis W. McKeehan, B. S., Instructor in Physics
Franklin R. McMillan, C. E., Instructor in Drawing
Carl M. Melom, M. A., Instructor in Spanish
Charles W. Nichols, M. A., Instructor in Rhetoric
Peter Peterson, Instructor in Foundry Practice
Edward Quigley, Instructor in Forge Work
William H. Richards, Instructor in Carpentry
Frank B. Rowley, B. S., M. E., Instructor in Drawing
Edgar K. Soper, B. A., Instructor in Economic Geology

Winifred Gregory, Librarian

Admission

The courses leading to the degrees of E. M. and Met. E. may be completed in either four or five years. The course leading to the degree of E. M. (Geology) may be completed in five years.

Students may enter the School of Mines without preparation in higher algebra and solid geometry. Such students must enter the five-year courses.

Students who enter the four-year courses with higher algebra and solid geometry must pass the entrance examinations in mathematics given by the School. State High School Board certificates will be accepted for all subjects except mathematics.

It is recommended that students who come poorly prepared in mathematics enter the five-year courses.

Examinations for admission in subjects other than mathematics will be held at the beginning of the year. Examinations in mathematics are held in June and September. See calendar and program of examinations.

No senior will be registered for first semester's work after September 12, 1911.

No other students will be registered for first semester's work after September 30, 1911, nor any student for second semester's work after February 17, 1912.

All applicants should present themselves to the Dean of the School of Mines, Room 25, School of Mines Building, who will furnish them with application blanks and directions covering examinations and registration.

Women will not be admitted to any course offered in the School of Mines.

GENERAL REGULATIONS GOVERNING ADMISSION

I. Students will be admitted to the freshman class on passing the regular entrance examinations.

II. No student will be admitted if conditioned in more than three half-year subjects, or their equivalent. No conditions, however, in entrance mathematics shall be allowed except upon special permission of the Department of Mathematics.

III. Graduates of any Minnesota State high school will be admitted to the five-year courses without examination, or to the four-year courses with examination in mathematics, provided—

(1) That the school maintain a full four-year course of high school work.

(2) That the applicant present to the Registrar the principal's certificate showing the satisfactory completion of all studies required for admission to the desired University course.

IV. Graduates of Minnesota State high schools who are deficient in not more than three half-year subjects or their equivalent, may be excused from entrance examinations in such subjects as the Enrollment Committee may decide upon; such candidates should present themselves to the committee not later than Tuesday of examination week.

V. Graduates of Minnesota State high schools whose principal's certificate shows them to be deficient in more than three half-year subjects or their equivalent, even though they have made such additional preparation as they deem necessary, must take, nevertheless, the regular entrance examination in all subjects, as provided in sections I. and II., unless excused by vote of the faculty; and persons wishing to present reasons for such excuse should report to the Enrollment Committee not later than Tuesday of examination week.

VI. Graduates of the advanced courses of Minnesota normal schools will be admitted upon the same terms as graduates of State high schools.

VII. Any Minnesota high school or academy not under supervision of the State High School Board, but requiring for graduation a four years' course, exclusive of the common school branches, conforming essentially in distribution of time to the entrance requirements of at least one of the University courses, will, upon application, be inspected by a committee, and, after favorable recommendation, may be accredited by the faculty in all respects as are the State high schools, provided—

(1) That the school be open to inspection at any time by the University.

(2) That it take such supplementary examinations as may be prescribed from time to time.

VIII. Graduates from schools in other states, whose diplomas admit to reputable colleges in the state in which the school is located, will be received subject to the regulations that apply to graduates of Minnesota State high schools.

IX. Applicants coming from schools not included in any of the above classes must take the regular entrance examinations or present State High School Board certificates.

In all cases the faculty reserves the right to require a student to take supplementary examinations if he does not sustain himself creditably in his course.

The Enrollment Committee will meet every day during the week commencing Tuesday, September 12th, in School of Mines Building, room 25, at 9 o'clock, a. m.

REQUIREMENTS FOR ADMISSION TO THE FIVE-YEAR COURSES

Required Subjects:

English	*four credits
Elementary Algebra	one credit
Plane Geometry	one credit
Electives	nine credits

REQUIREMENTS FOR ADMISSION TO THE FOUR-YEAR COURSES

Required Subjects:

English	*four credits
Elementary Algebra	one credit
Higher Algebra	one-half credit
Plane Geometry	one credit
Solid Geometry	one-half credit
Electives	eight credits

Electives (Eight credits must be selected from this list for the four-year courses and nine credits for the five-year courses.)

LATIN

Grammar, one credit
Caesar, four books, one credit
Cicero, six orations, one credit
Virgil, six books, one credit

GREEK

Grammar, one credit
Anabasis, four books, one credit

*Three credits will satisfy the English requirement when the applicant pre sents four credits in one foreign language. In this case a sufficient number of elect ves must be presented to make a total of fifteen entrance credits.

GERMAN
- Grammar, one credit
- Literature, one credit

FRENCH
- Grammar, one credit
- Literature, one credit

SPANISH
- Grammar, one credit
- Literature, one credit

SCANDINAVIAN LANGUAGES
- Grammar, one credit
- Literature, one credit

HISTORY
- Ancient, to Charlemagne, one credit
- Modern, from Charlemagne, one credit
- English, one-half credit
- Senior American, one-half credit

AMERICAN GOVERNMENT, one-half credit
ELEMENTARY ECONOMICS, one-half credit
HISTORY OF COMMERCE, one-half credit
COMMERCIAL GEOGRAPHY, one-half or one credit
PHYSICS, one credit
CHEMISTRY, one credit
BOTANY, one-half or one credit
ZOOLOGY, one-half or one credit
ASTRONOMY, one-half credit
GEOLOGY, one-half credit
PHYSIOGRAPHY, one-half credit

Not more than four credits are allowed in the following vocational subjects, including business subjects, manual subjects, domestic science, and agriculture.

BUSINESS SUBJECTS
- Business Law, one-half credit
- Business Arithmetic, one-half credit
- Elementary Bookkeeping, one-half credit
- Advanced Bookkeeping and Business Practice, one credit
- Stenography and Typewriting, two credits

MANUAL SUBJECTS
- Freehand Drawing, two credits
- Mechanical Drawing, two credits
- Shop Work, two credits
- Modeling and Wood Carving, one credit

Domestic Art and Science, two credits

Agriculture. One to four credits from schools receiving special state aid for agriculture, and also from other schools in which such course in agriculture is approved by the State High School Board, as fast as the said schools are prepared to offer work in agriculture.

DESCRIPTION OF SUBJECTS ACCEPTED FOR ADMISSION

A description of the subjects accepted for admission to the University will be found in the Bulletin of General Information, which will be sent to any address upon application to the Registrar, University of Minnesota, Minneapolis, Minnesota.

ADVANCED STANDING

The University accepts records from other colleges for credit to advanced standing. Such records are accepted as far as they are equivalent to the work in this University, subject to the approval of the departments concerned. In bringing records from other institutions, the certificates must be on the official blanks of the institution granting the certificate, and should show:

1. The subjects studied and ground covered.
2. The time spent upon each subject.
3. In case of laboratory subjects, a concise statement of work done.
4. The result—it is sufficient to state the subjects were creditably completed.

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee.

DAILY ROUTINE

The daily session is divided into eight recitation periods of fifty minutes each, four in the morning and four in the afternoon. The morning session begins at 8:30 and closes at 12:35 o'clock. A general assembly of the faculty and students is held at 10:25 o'clock, at which there are brief and simple religious exercises. The noon hour extends from 12:35 to 2 o'clock. The afternoon session begins at 2 o'clock, and continues until 5:40. Work extends through six days of the week.

EXAMINATIONS

Students failing to receive a semester mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his yearly average in all subjects and present himself for supplementary examinations, according to the program given on page 4.

Students failing to receive a semester mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

All students who voluntarily register for military drill shall be required to drill the entire year and be subject to the same rules and regulations as other cadets. Such students must receive credit or honorable dismissal from the department before graduating.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

No other supplementary examination will be given. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to present themselves for final examination at the end of the first or second semester will be given zero on the examinations.

Students whose absences in either semester exceed four weeks in the aggregate are not permitted to take examinations without special permission of the faculty.

A fee of five dollars per subject is required for each special examination.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

GRADUATION

Students completing courses of study to the satisfaction of the faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations held at the end of the second semester. Irregular attendance will debar a student from entering all final examinations.

THESES

The thesis work is intended to bring in review and connect the work in mining and metallurgy, geology and mineralogy, mechanical and electrical engineering, mathematics and mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for mining engineers and the working out of a metallurgical problem in the case of candidates for the metallurgical degree.

As much latitude as possible will be allowed in the choice of type of deposit and location. Outlines will be furnished setting forth the lines of investigation which will enable the student to select a suitable project during the junior field work. Prior to final registration for first semester senior year each student is required to submit to the department concerned an outline of the chosen project, accompanied with a topographic map and a sufficient number of photographs to clearly represent the locality.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in first semester senior year.

All preliminary work must be done and final work on project must be under way by December 1st and submitted for final approval by April 9th. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30th. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the school.

Special Information

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E. M.), Engineer of Mines in Geology [E. M. (Geology)], and Metallurgical Engineer (Met. E.) respectively.

The degree of Met. E. may be conferred upon a candidate who received the degree of E. M. in four or five years, and vice versa, provided such candidate completes an additional year's work at the school and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and Mechanic Arts, and in the School of Technical and Applied Chemistry, who contemplate taking a degree in this school after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

SUMMARY OF EXPENSES

FIRST YEAR—Five-Year Courses

*Incidental fee	$30.00
Chemical laboratory fee	10.00
Shop work	9.00
Books	20.00
Note books and supplies	5.00

FRESHMAN YEAR

*Incidental fee	$30.00
Chemical laboratory fee	10.00
Mineralogical laboratory fee	6.00
Assaying laboratory fee	15.00
Books	25.00
Draughting instruments	15.00
Note books and supplies	5.00

SOPHOMORE YEAR

*Incidental fee	$30.00
Chemical laboratory fee	14.00
Physics laboratory fee	6.00
Books	15.00
Note books and supplies	5.00

JUNIOR YEAR

*Incidental fee	$30.00
Experimental laboratory	9.00
Trip to the mines	$150.00 to 200.00
Books	30.00
Note books and supplies	5.00

SENIOR YEAR

*Incidental fee	$30.00
Chemical laboratory fee	10.00
Electrical laboratory fee	5.00
Ore testing laboratory fee	10.00
Experimental laboratory fee	6.00
Books	30.00
Note books and supplies	5.00

*For non-residents the incidental fee is $60 per year.

Good board can be obtained at a cost varying from $3.00 to $4.00 per week. Room rent varies from $5.00 to $15.00 per month. With two occupying one room, the rent per student would be considerably lower.

ORGANIZATION

The organization of the School of Mines dates back to 1889, when the general faculty of the University recommended to the Board of Regents its establishment. In 1891 the legislature of the State of Minnesota voted an appropriation for establishing and equipping the school. Two annual appropriations have since been made for its support. The legislature of 1901 appropriated $47,500 for a new School of Mines Building. In 1903 the legislature appropriated $25,000 for completing and equipping the School of Mines Building, and in 1905 an additional sum was provided for equipment.

SCHOOL OF MINES BUILDING

The School of Mines Building is designed to accommodate only the technical work of the School of Mines, as adequate building accommoda-

tions and equipment have already been furnished for chemistry, geology, mineralogy, drawing, and mechanical and electrical engineering. The building is 150 feet long by 65 feet wide. It is a brick building three stories high. The lower floor is occupied by the assaying and metallurgical laboratories; the second floor contains offices, two large lecture rooms, a department library, and a museum; the third floor provides two quiz rooms, a large, well-lighted draughting room, a thesis room, a dark room, and a blue print room. This building makes possible the development of the work already begun and offers facilities for more extended work along technical lines.

LOCATION

The University of Minnesota is located in the city of Minneapolis, on the east bank of the Mississippi River. The School of Mines has its buildings and laboratories on the same ground. Students of the School of Mines have, therefore, all the opportunities afforded by a large university.

Minneapolis is surrounded by, and is in direct communication with, several important mining and smelting districts. As the city is a railroad center, all possible transportation facilities are available.

FIELD WORK

Field work is conducted at the iron mines in the northern part of this state, in the copper and iron regions of Michigan, in the mines and smelters of Montana, Colorado, Utah, and California, and in the coal mines of Pennsylvania.

At least one of these districts will be visited by each class, affording splendid opportunities for study and observation.

The field work in mining and metallurgy consists of one trip at the close of the junior year. For details see pages 32 and 39.

Students must deposit with **Accountant,** at least **two weeks** before time set for the departure of class, a sum sufficient to cover following expense items:

1st. Board and lodging.
2d. Necessary mine supplies.

Transportation and incidental expenses are not included in the above items and must be met individually.

A statement of expenditures will be rendered at the close of the work and any balance existing will be refunded.

The amount of deposit required will vary according to the locality visited, and will be announced each year when arrangements for the trip are completed.

THE ELLIOTT SCHOLARSHIP LOAN FUND

To fulfill the wish of the late Dr. A. F. Elliott to aid young men who find their efforts to obtain a practical education embarrassed through lack of means, the sum of $5,000 was placed in the hands of the Board of Regents as a scholarship fund. The income from this fund is loaned students in the School of Mines on the following conditions: the financial needs of the applicant, his scholarship, moral character, enthusiasm shown in his work, and promise of usefulness in his profession. When money is available, it may be loaned to pay the expenses of worthy students during sickness. The loans are to be repaid, without interest, at the earliest convenience of the recipients.

LIBRARY

The library consists of about two thousand five hundred volumes. This number represents only those works that treat directly of mining and metallurgical subjects.

The school has a complete set of the leading mining and metallurgical journals, and other similar books of reference. The leading periodicals are accessible to all. Constant references in lectures compel the student to keep himself well informed as to the latest methods, machinery, and changes in practice going on in his special line of work.

In addition to the above, many thousand volumes on chemistry, mineralogy, and geology complete a most valuable working and reference library. A card index is kept of all articles of value and interest appearing in the leading periodicals.

PHOTOGRAPHY

Photographs of surface and underground appliances, metallurgical plants, copies of drawings and other photographs are indispensable to the study of mining and metallurgy. With the report of his field work every student is expected to present photographs, as well as sketches, of various objects under consideration. There is also a very complete set of lantern slides illustrating the principal methods of underground workings and metallurgical plants, at home and abroad. Several hundred slides have been made in the department's laboratory which bear directly on the work done in Minnesota and the neighboring northwest. Many valuable photographs are constantly being made. Blue prints of these are given students as illustrations. Much time, usually spent in making sketches and diagrams, is thus saved.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thorough courses in mechanics, mathematics, physics, chemistry, mineralogy and geology:

(A) **Assaying**—to determine if ore has value for treatment. (B) **Mining engineering**—to furnish material for treatment. (C) **Ore testing**—to determine best method of treatment. (D) **Ore dressing**—furnishing products for metallurgical treatment. (E) **Metallurgy**—smelting and refining ores and ore dressing products; reduction to metals.

Courses in Mining Engineering

Courses Leading to the Degree of E. M.

FIRST YEAR—FIVE-YEAR COURSES

FIRST SEMESTER

CHEMISTRY 1, six hours, Miss Cohen and Assistants
MATHEMATICS 1, four hours, Assistant Professor Lambert
MATHEMATICS 3, three hours, Professor Comstock
MECHANICAL ENGINEERING 1 and 2, six hours, Assistant Professor Shipley
RHETORIC 15, four hours, Mr. Nichols
SPANISH 11, three hours, Mr. Melom

SECOND SEMESTER

CHEMISTRY 1, six hours, Miss Cohen and Assistants
MATHEMATICS 2, three hours, Assistant Professor Lambert
MATHEMATICS 4, three hours, Professor Comstock
MECHANICAL ENGINEERING 3, six hours, Mr. Peterson
RHETORIC 15, four hours, Mr. Nichols
SPANISH 11, three hours, Mr. Melom

FRESHMAN YEAR—FOUR AND FIVE-YEAR COURSES

FIRST SEMESTER

CHEMISTRY 2, eight hours, Professor Frankforter and Mr. Frary
DESCRIPTIVE GEOMETRY 13, three hours, Professor Kirchner
DRAWING 11, four hours, Mr. French
MATHEMATICS 5, five hours, Assistant Professor Lambert
MINERALOGY 1, eight hours, Professor Hall and Assistant Professor Grout

SECOND SEMESTER

CHEMISTRY 3, eight hours, Professor Frankforter and Mr. Frary
DRAWING 12, four hours, Mr. French
DRAWING 14, four hours, Professor Kirchner and Mr. McMillan
MATHEMATICS 6, five hours, Assistant Professor Lambert

METALLURGY 1, twelve hours, Professors Appleby, Christianson, and Pease
MINERALOGY 2, four hours, Professor Hall and Assistant Professor Grout

SOPHOMORE YEAR—FOUR AND FIVE-YEAR COURSES

FIRST SEMESTER

CHEMISTRY 4, eight hours, Professor Sidener
DESCRIPTIVE GEOMETRY 15, two hours, Professor Kirchner
DRAWING 17, four hours, Mr. Rowley and Mr. French
MATHEMATICS 7, five hours, Assistant Professor Lambert
METALLURGY 3, three hours, Professor Christianson
PHYSICS 1 and 2, five hours, Professor Zeleny, Mr. Holman, and Mr. McKeehan

SECOND SEMESTER

CHEMISTRY 5, eight hours, Professor Sidener
DRAWING 18, four hours, Mr. Rowley and Mr. French
GEOLOGY 3, three hours, Mr. Soper
MATHEMATICS 8, five hours, Assistant Professor Lambert
METALLURGY 4, three hours, Professor Christianson
MINING 1, four hours, Professor McCarty
PHYSICS 3 and 4, five hours, Professor Zeleny, Mr. Holman, and Mr. McKeehan
FIELD WORK 3 (a), first two weeks in June, Mr. Soper

JUNIOR YEAR—FOUR AND FIVE-YEAR COURSES

FIRST SEMESTER

EXPERIMENTAL ENGINEERING 1, four hours, Assistant Professor Shoop
GEOLOGY 4, three hours, Professor Hall and Mr. Soper
GEOLOGY 9, four hours, Mr. Bowles
MECHANICS 9, five hours, Professor Comstock
MECHANICAL ENGINEERING 18, two hours, Professor Flather
METALLURGY 5, four hours, Professor Pease
MINING 2, five hours, Professor van Barneveld
MINING 3, five hours, Professor McCarty and Assistant Professor Kingston

SECOND SEMESTER

EXPERIMENTAL ENGINEERING 2, four hours, Assistant Professor Shoop

GEOLOGY 10, four hours, Mr. Bowles
MECHANICS 10, three hours, Professor Comstock
MECHANICS 12, five hours, Professor Comstock
METALLURGY 6, four hours, Professor Pease
MINING 2, five hours, Professor van Barneveld
MINING 5, five hours, Professor McCarty
MINING 7, six hours, Assistant Professor Kingston
FIELD WORK. Months of May, June, July, and August

Mine Surveying 8, beginning about May 1st.	Professor van Barneveld Professor McCarty Assistant Professor Kingston
Metallurgy 8, one week	Professor Appleby Professor Christianson Professor Pease
Practical Mining 9, six weeks	Professor van Barneveld Professor McCarty Assistant Professor Kingston

SENIOR YEAR—FOUR AND FIVE-YEAR COURSES

FIRST SEMESTER

CHEMISTRY 14, eight hours, Professor Sidener
ELECTRICAL ENGINEERING 4, five hours, Assistant Professor Ryan
GEOLOGY 12, four hours, Mr. Soper
MECHANICS 13, five hours, Professor Comstock
METALLURGY 2, ten hours, Professors Appleby, Christianson, and Pease
MINING 4, five hours, Professor van Barneveld
MINING (Thesis) 10, two hours, Professor van Barneveld and Assistants

SECOND SEMESTER

CHEMISTRY 18, eight hours, Professor Sidener
EXPERIMENTAL ENGINEERING 5, four hours, Professor Kavanaugh
GEOLOGY 13, four hours, Mr. Soper
MECHANICS 14, six hours, Professor Comstock
MINING 4, five hours, Professor van Barneveld
MINING (Designs and Specifications) 6, eight hours, Professors van Barneveld and Comstock
MINING (Thesis) 10 four hours, Professor van Barneveld and Assistants

Courses Leading to the Degree of E. M. (Geology)

FIRST YEAR

FIRST SEMESTER

CHEMISTRY 1, six hours, Miss Cohen and Assistants
DESCRIPTIVE GEOMETRY 13, three hours, Professor Kirchner
DRAWING 11, four hours, Mr. French
FRENCH 1 or 3, three hours, Professor Benton and Assistants
or
GERMAN 1 or 4, three hours, Professor Moore and Assistants
MATHEMATICS 1, four hours, Assistant Professor Lambert
RHETORIC 15, four hours, Mr. Nichols

SECOND SEMESTER

CHEMISTRY 1, six hours, Miss Cohen and Assistants
DRAWING 12, four hours, Mr. French
DRAWING 14, four hours, Professor Kirchner and Mr. McMillan
FRENCH 1 or 3, three hours, Professor Benton and Assistants
or
GERMAN 1 or 4, three hours, Professor Moore and Assistants
MATHEMATICS 2, three hours, Assistant Professor Lambert
RHETORIC 15, four hours, Mr. Nichols

FRESHMAN YEAR

FIRST SEMESTER

CHEMISTRY 2, eight hours, Professor Frankforter and Mr. Frary
FRENCH 2 or 5, three hours, Professor Benton and Assistants
or
GERMAN 3 or 7, three hours, Professor Moore and Assistants
MATHEMATICS 5, five hours, Assistant Professor Lambert
MINERALOGY 1, eight hours, Professor Hall and Assistant Professor Grout

SECOND SEMESTER

CHEMISTRY 3, eight hours, Professor Frankforter and Mr. Frary
FRENCH 2 or 5, three hours, Professor Benton and Assistants
or
GERMAN 3 or 7, three hours, Professor Moore and Assistants
MATHEMATICS 6, five hours, Assistant Professor Lambert

METALLURGY 1, twelve hours, Professors Appleby, Christianson, and Pease
MINERALOGY 2, four hours, Professor Hall and Assistant Professor Grout

SOPHOMORE YEAR

FIRST SEMESTER

CHEMISTRY 4, eight hours, Professor Sidener
DESCRIPTIVE GEOMETRY 15, two hours, Professor Kirchner
DRAWING 17, four hours, Mr. Rowley and Mr. French
MATHEMATICS 7, five hours, Assistant Professor Lambert
MINERALOGY (Advanced), three hours
PHYSICS 1 and 2, five hours, Professor Zeleny, Mr. Holman, and Mr. McKeehan

SECOND SEMESTER

CHEMISTRY 5, eight hours, Professor Sidener
DRAWING 18, four hours, Mr. Rowley and Mr. French
GEOLOGY 3, three hours, Mr. Soper
MATHEMATICS 8, five hours, Assistant Professor Lambert
METALLURGY, three hours
MINING 1, four hours, Professor McCarty
PHYSICS 3 and 4, five hours, Professor Zeleny, Mr. Holman, and Mr. McKeehan
FIELD WORK IN GEOLOGY, four weeks

JUNIOR YEAR

FIRST SEMESTER

GEOLOGY 4, three hours, Professor Hall and Mr. Soper
GEOLOGY 9, four hours, Mr. Bowles
MECHANICS 9, five hours, Professor Comstock
MINING 2, five hours, Professor van Barneveld
MINING 3, five hours, Professor McCarty and Assistant Professor Kingston
PALEONTOLOGY, three hours
ELECTIVES, six hours

SECOND SEMESTER

GEOLOGY 10, four hours, Mr. Bowles
MECHANICS 10, three hours, Professor Comstock
MINING 2, five hours, Professor van Barneveld
MINING 5, five hours, Professor McCarty
MINING 7, six hours, Assistant Professor Kingston

Paleontology (Invertebrate), nine hours
Surveying (Geological), two hours
Electives, four hours
Field Work. Months of May, June, July, and August
Mine Surveying 8, beginning about May 1st.
Professor van Barneveld
Professor McCarty
Assistant Professor Kingston
Practical Mining 9, six weeks
Professor van Barneveld
Professor McCarty
Assistant Professor Kingston
Practical Geology, four weeks

SENIOR YEAR

FIRST SEMESTER

Geology 12, four hours, Mr. Soper
Geology of Lake Superior District, five hours
General and Mining Law, three hours
Mechanics 13, five hours, Professor Comstock
Mining 4, five hours, Professor van Barneveld
Thesis, ten hours

SECOND SEMESTER

Geology 13, four hours, Mr. Soper
Geology of Western Mining Districts, five hours
Geological Mine Models, etc., ten hours
Mining 4, five hours, Professor van Barneveld
Thesis, ten hours

DEPARTMENT OF MINING ENGINEERING

Mining engineering extends through the sophomore, junior, and senior years. The subjects given, together with the sequence necessary, are treated in the accompanying outline of the course.

Until the first semester of the junior year, the course consists of lectures and recitations only. In the subsequent work, text-books are used in connection with the lectures.

In the senior year, problems in hoisting, hauling, pumping, ventilation, and similar subjects become an important part of the work.

DESIGNS AND SPECIFICATIONS

The student makes, in connection with his thesis work, working drawings of mine cars, skips, and other parts of mine equipment that are usually designed and made at the mine.

MINE SURVEYING

The work in surveying is given in the junior year and is designed solely for mining engineers.

The work begins with the elements of plane surveying with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. This is followed by a course in mine mapping during the second semester of junior year and six weeks of field work as follows: Beginning with the first Monday in May the class meets daily for the practice of plane surveying at some readily accessible locality (to be announced each year). The duration of this course is four weeks. Eight hours a day.

The students are divided into squads of two or four, and each is required to complete satisfactorily the following exercises and surveys:

1. Chaining
2. Compass reading
3. Adjustment of hand levels and practice in leveling
4. Adjustment and use of wye levels
5. Adjustment of mining transit
6. Reading angles
7. Traverse with steel tape
8. Azimuth traverse with stadia
9. Determination of meridian, latitude, and time by solar and stellar observations
10. Survey of mining claim according to the regulations of the U. S. Government
11. Measurement of earthwork
12. Laying out railroad tangents, curves, and crossings

Each squad must provide itself with a 6-foot steel tape, graduated to hundredths.

After the completion of this work from ten days to two weeks are spent in the actual underground survey of a mine or part of a mine in some mining district in Minnesota or Michigan.

A full equipment of surveying instruments of the latest and best makes is furnished to each squad for this work.

Students who furnish satisfactory evidence of proficiency in this work may be given credit therefor. The department, however, reserves the right in any case to require such students to take a theoretical or a practical examination or both.

FIELD WORK IN MINING

SOPHOMORE YEAR

After the close of the field work in geology (first two weeks in June) members of the sophomore class are required to engage for six weeks in underground mining work on the Minnesota or Michigan iron ranges, for which they may receive wages.

JUNIOR YEAR

Upon termination of the junior field work in mine surveying and in metallurgy (not later than July 1st) the members of the junior class are required to spend at least six weeks in practical work in one or more of the metal mines of the west. Four weeks must be spent in actual underground mining for which the student may receive wages. At least two weeks must be devoted to a special course of observation and study of mining methods and mine plant, following special instructions to be given yearly. The department will render all possible assistance in locating students in the camps of their choice.

Each student must keep a diary and must record therein, in minute detail, all observations and sketches. He must in person submit this diary to the department not later than October 2d.

Field work will reopen at the University September 12th. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in mine mapping, mining, and metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned.

The program covering this work is as follows: Mine Mapping, September 12th-16th, inclusive; Mining, September 18th-26th; Metallurgy, September 27th-October 2d.

On October 2d all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before October 2d. These reports shall become the property of the school.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reason, fail to complete this work in regular course, he may, with the consent of the department,

be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

ORE DRESSING

The lectures and recitations in ore dressing extend through the second semester of the junior year, and comprise the detailed study of ore dressing and concentrating machinery, together with the study of typical combinations of dressing machines as found in the several mining districts of the United States.

In connection with the theoretical work, the ore dressing and testing plant of the school is utilized for practical illustrations.

Courses in Metallurgy

Courses Leading to the Degree of Met. E.

FIRST YEAR—FIVE-YEAR COURSES

FIRST SEMESTER

Chemistry 1, six hours, Miss Cohen and Assistants
Mathematics 1, four hours, Assistant Professor Lambert
Mathematics 3, three hours, Professor Comstock
Mechanical Engineering 1 and 2, six hours, Assistant Professor Shipley
Rhetoric 15, four hours, Mr. Nichols
Spanish 11, three hours, Mr. Melom

SECOND SEMESTER

Chemistry 1, six hours, Miss Cohen and Assistants
Mathematics 2, three hours, Assistant Professor Lambert
Mathematics 4, three hours, Professor Comstock
Mechanical Engineering 3, six hours, Mr. Peterson
Rhetoric 15, four hours, Mr. Nichols
Spanish 11, three hours, Mr. Melom

FRESHMAN YEAR—FOUR AND FIVE-YEAR COURSES

FIRST SEMESTER

Chemistry 2, eight hours, Professor Frankforter and Mr. Frary
Descriptive Geometry 13, three hours, Professor Kirchner
Drawing 11, four hours, Mr. French
Mathematics 5, five hours, Assistant Professor Lambert
Mineralogy 1, eight hours, Professor Hall and Assistant Professor Grout

SECOND SEMESTER

Chemistry 3, eight hours, Professor Frankforter and Mr. Frary
Drawing 12, four hours, Mr French
Drawing 14, four hours, Professor Kirchner and Mr. McMillan
Mathematics 6, five hours, Assistant Professor Lambert

Metallurgy 1, twelve hours, Professors Appleby, Christianson, and Pease
Mineralogy 2, four hours, Professor Hall and Assistant Professor Grout

SOPHOMORE YEAR—FOUR AND FIVE-YEAR COURSES

FIRST SEMESTER

Chemistry 4, eight hours, Professor Sidener
Descriptive Geometry 15, two hours, Professor Kirchner
Drawing 17, four hours, Mr. Rowley and Mr. French
Mathematics 7, five hours, Assistant Professor Lambert
Metallurgy 3, three hours, Professor Christianson
Physics 1 and 2, five hours, Professor Zeleny, Mr. Holman, and Mr. McKeehan

SECOND SEMESTER

Chemistry 5, eight hours, Professor Sidener
Drawing 18, four hours, Mr. Rowley and Mr. French
Geology 3, three hours, Mr. Soper
Mathematics 8, five hours, Assistant Professor Lambert
Metallurgy 4, three hours, Professor Christianson
Mining 1, four hours, Professor McCarty
Physics 3 and 4, five hours, Professor Zeleny, Mr. Holman, and Mr. McKeehan
Field Work 3 (a), first two weeks in June, Mr. Soper

JUNIOR YEAR—FOUR AND FIVE-YEAR COURSES

FIRST SEMESTER

Experimental Engineering 1, four hours, Assistant Professor Shoop
Geology 4, three hours, Professor Hall and Mr. Soper
Geology 9, four hours, Mr. Bowles
Mechanics 9, five hours, Professor Comstock
Mechanical Engineering 18, two hours, Professor Flather
Metallurgy 5, four hours, Professor Pease
Mining 2, five hours, Professor van Barneveld
Mining 3, five hours, Professor McCarty and Assistant Professor Kingston

SECOND SEMESTER

Experimental Engineering 2, four hours, Assistant Professor Shoop
Geology 10, four hours, Mr. Bowles
Mechanics 10, three hours, Professor Comstock

MECHANICS 12, five hours, Professor Comstock
METALLURGY 6, four hours, Professor Pease
MINING 2, five hours, Professor van Barneveld
MINING 5, five hours, Professor McCarty
MINING 7, six hours, Assistant Professor Kingston
FIELD WORK. Months of May, June, July, and August.

Mine Surveying 8, beginning about May 1st.	Professor van Barneveld Professor McCarty Assistant Professor Kingston
Metallurgy 8, one week	Professor Appleby Professor Christianson Professor Pease
Practical Mining 9, six weeks	Professor van Barneveld Professor McCarty Assistant Professor Kingston

SENIOR YEAR—FOUR AND FIVE-YEAR COURSES

FIRST SEMESTER

CHEMISTRY 14, eight hours, Professor Sidener
ELECTRICAL ENGINEERING 4, five hours, Assistant Professor Ryan
GEOLOGY 12, four hours, Mr. Soper
MECHANICS 13, five hours, Professor Comstock
MINING 4, five hours, Professor van Barneveld
METALLURGY 2, ten hours, Professor Appleby, Christianson, and Pease

SECOND SEMESTER

CHEMISTRY 18, eight hours, Professor Sidener
CHEMISTRY 16, six hours, Mr. Frary
EXPERIMENTAL ENGINEERING 5, four hours, Professor Kavanaugh
MECHANICS 14, six hours, Professor Comstock
METALLURGY 7, three hours, Professor Christianson
METALLURGY 9, four hours, Professors Appleby and Comstock
MINING 4, five hours, Professor van Barneveld

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use.

The practical work consists in visits to smelting and refining works which are accessible. The work in metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags are shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students, who are required to make up the necessary charges and submit their reports in detail. This work is offered to students completing the necessary courses in mineralogy and chemistry.

The Assay Laboratories are located in the School of Mines Building and consist of:

1st. Preparation room. This room is 62 feet long by 36 feet wide and accommodates 66 students. Here samples and reagents are weighed preparatory to assaying. Each student is furnished with a complete set of apparatus, including a pulp balance for individual use. All operations are therefore conducted with the greatest economy of time and entirely apart from the furnace room. The separation of the preparation room from the furnace room is of greatest importance. Nearly all ores are crushed and pulverized by suitable machines run by electric motors. Students are compelled to pulverize by hand a minimum number of samples, thereby saving much time for extended and advanced work in special lines.

2d. Furnace room. This room is 60 feet long by 42 feet wide. The high ceiling and special ventilation provided for this room make it a most comfortable assay furnace room. It provides for the accommodation of twelve double-decked muffle furnaces, twenty-four crucible furnaces, and twelve gasoline furnaces. After the sample has been placed in a suitable vessel for fusion, it is taken to the furnace room, which communicates directly with the preparation room.

3d. Balance room. This room is 31 feet long by 16 feet wide. In this room are various types of balances for accurately weighing gold and silver beads and bullion. The room is specially lighted by electric cove lights from the ceiling. The balances are placed on heavy brick piers which are independent of the walls of the building.

ORE TESTING

The lectures treat of the use and purposes of all the machinery connected with the subject, supplemented by detailed drawings.

There are complete testing works connected with the department where the student may see the working of, and handle for himself, crushers, rolls, Huntington mill, concentrating machinery, such as vanners, buddles, jigs, pan for amalgamation, settlers, reverberatory furnaces for oxidizing and oxidizing-chloridizing roasts, leaching and chlorination plants, as well as sizing apparatus and hydraulic separators. Sufficiently large amounts of ore are given to make the necessary tests upon the different machines and the students report the best method of treatment. The first semester of the senior year is devoted to instruction and laboratory work, and is required of students both in mining and metallurgy.

The ore testing works meet educational as well as commercial needs.

Educational. The ore testing plant acquaints the student with the construction and manipulation of the principal typical machines used in the leading ore dressing establishments of the country. It is here that students in mining and metallurgical engineering get the requisite practical experience. They handle all machines and operate on sufficiently large amounts of material to determine the methods best suited to a given ore to extract the largest amount of metal with the least possible loss.

Commercial. Ore testing works are an important factor in mining and metallurgical projects. The commercial object is to determine the best method of treating a given ore so as to yield the largest percentage of the metal it contains at the least possible cost. Samples varying from 500 pounds to car load lots can be treated by various methods.

The ore testing works are located on the east bank of the Mississippi between the Great Northern and Northern Pacific railroads. Located at this point on the University campus, it offers the very best facilities for both educational and commercial purposes.

As the funds appropriated for the erection of such a plant were sufficient to purchase only the necessary machinery, the business men of Minneapolis generously provided a suitable building. This building, 94 by 66 feet, is built of brick and stone.

Machinery. The plant contains all the machinery necessary to illustrate the various processes of ore testing, viz.: A Bridgman mechanical sampler, size B; a link belt bucket elevator; a pulley feeder complete; a pair of 12½ by 12 geared rolls complete; a four compartment spitzkasten; a three compartment Hartz jig; a Collum jig complete with cone for driving; a three and a half foot Huntington mill complete; a three stamp mill, 275-pound stamps; a five stamp mill, 850-pound stamps; a Challenge automatic feeder for five-stamp battery; a suspended Challenge feeder for three-stamp battery; a Tulloch feeder for Huntington mill; a single deck buddle, twelve feet in diameter; a four-foot plain belt Frue vanner; a Cammett concentrator; a Hooper pneumatic concentrator; a Century drop motion jig; a three-foot amalgamating pan; a five-foot settler; a Bruckner roasting furnace, with fire box on wheels; a chlorination barrel; a battery tightener; a two-horse power vertical boiler; a steam drying pan; three trommels, with driving arrangement and gears; a one thousand pound Reedy elevator, complete with worm gear; two overhead crawls, each with eighty-foot track; one-ton pulley block; a quarter-ton pulley block; a scoop car, with flat wheels; two twenty-horse power electric motors; three MacDermott automatic samplers, etc.

FIELD WORK IN METALLURGY

At the end of junior year opportunity is given the student to study metallurgical operations at one or more smelting works. This work will begin about June 22d. Not over one week's time will be devoted to this work.

The student must keep a diary and record therein, in minute detail, all work done, his observations and sketches. He must, **in person,** submit this diary to the department not later than September 12th.

Field work will reopen at the University September 12th. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in mine mapping, mining, and metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned.

The program covering this work is as follows: Mine Mapping, September 12th-16th, inclusive; Mining, September 18th-26th; Metallurgy, September 27th-October 2d.

On October 2d all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn

to scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before October 2d. These reports shall become the property of the school.

Departmental Statements

CHEMISTRY

George B. Frankforter, Ph. D., Professor of Chemistry
Charles F. Sidener, B. S., Professor of Chemistry
Francis C. Frary, M. S., Instructor in Chemistry
Lillian Cohen, M. S., Instructor in Chemistry

1. General Chemistry — Miss Cohen
*Six credits (six hours per week) — Both semesters
Required of first-year students, five-year courses.
Recitation and laboratory work. The course includes a study of the common elements and their compounds, with an introduction to the modern theories of chemistry.

2. General and Qualitative Analysis — Professor Frankforter and Mr. Frary
Five credits (two lectures, six laboratory hours per week) — First semester
Required of freshmen.
The course includes special general chemistry and the reactions of the metals as applied to their separation and identification.

3. Qualitative Analysis — Professor Frankforter and Mr. Frary
Five credits (two lectures, six laboratory hours per week) — Second semester
Open to students completing 2. Required of freshmen.
The work in this course will include examination of alloys, minerals, slags, and other compounds.

4. Quantitative Analysis — Professor Sidener and Assistants
Five credits (two lectures, six laboratory hours per week) — First semester
Open to students completing 3. Required of sophomores.
The course includes an introduction to quantitative and a beginning of gravimetric analysis.

5. Volumetric Analysis — Professor Sidener and Assistants
Five credits (two lectures, six laboratory hours per week) — Second semester
Open to students completing 4. Required of sophomores.
The course includes an introduction to volumetric determinations with a discussion of standard solutions and the necessary stoechiometric calculations.

14. Special Problems — Professor Sidener and Assistants
Five credits (two lectures, six laboratory hours per week) — First semester
Open to students completing 5. Required of seniors.
The course includes the working out of various mineralogical, technological, and metallurgical problems, with work on ores of base metals, limestones, slags, etc.

*Note. A credit is one recitation or lecture hour per week, per semester. Two laboratory hours are equal to one credit.

16. Electro-Chemical Analysis — Mr. Frary
Four credits (two lectures, four laboratory hours per week) Second semester
Open to students completing 14. Required of seniors in Metallurgy.
The course includes the qualitative and quantitative separation of metals by electrolysis.

18. Iron and Steel Analysis — Professor Sidener and Assistants
Five credits (two lectures, six laboratory hours per week) Second semester
Open to students completing 14. Required of seniors.
The course includes the rapid determination of iron by the various methods, as well as the determination of associated elements, sulphur, phosphorus, silicon, manganese, carbon, and others.

DRAWING AND DESCRIPTIVE GEOMETRY

William H. Kirchner, B. S., Professor of Drawing and Descriptive Geometry
Frank B. Rowley, B. S., M. E., Instructor in Drawing
Franklin R. McMillan, C. E., Instructor in Drawing
Robert W. French, B. S., Instructor in Drawing

11. Freehand Drawing — Mr. French
Two credits (four drafting hours per week) First semester
Required of freshmen.
Sketching, lettering, and the elements of engineering drawing, representation of details of machines and structures, and the interpretation of working drawings.

12. Mechanical Drawing — Mr. French
Two credits (four drafting hours per week) Second semester
Open to students completing 11 and 13. Required of freshmen.
Continuation of course 11 as outlined above.
The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes.

13. Descriptive Geometry — Professor Kirchner
Two credits (one lecture, two drafting hours per week) First semester
Required of freshmen.
Representation; parallel and radial projection; perspective, pure and applied. Lettering, elementary problems, and exercises.

14. Topographical Drawing — Professor Kirchner and Mr. McMillan
Two credits (four drafting hours per week) Second semester
Open to students taking 12.
Maps and sketches. Brush and pen conventions.

15. Descriptive Geometry — Professor Kirchner
Two credits (two lecture hours per week) First semester
Open to students completing mathematics 6. Required of sophomores.
Continuation of course 13 as outlined above.
Projection—central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems.

17. Drafting — Mr. Rowley and Mr. French
Two credits (four drafting hours per week) — First semester
Open to students taking 15. Required of sophomores
Graphics, machine drafting, and structural drafting. Instruction in drafting room methods.

18. Drafting — Mr. Rowley and Mr. French
Two credits (four drafting hours per week) — Second semester
Open to students completing 17. Required of sophomores.
Continuation of course 17 as outlined above.

ELECTRICAL ENGINEERING

George D. Shepardson, M. A., M. E., Professor of Electrical Engineering
William T. Ryan, E. E., Assistant Professor of Electrical Engineering

4. Electric Power — Assistant Professor Ryan
Three credits (one lecture, four laboratory hours per week) — First semester
Open to students completing physics 1. Required of seniors in E. M. and Met. E. courses.
Elements of theory and practice of electrical measurements, wiring, dynamos, motors, and electric lighting.

EXPERIMENTAL ENGINEERING

William H. Kavanaugh, M. E., Professor of Experimental Engineering
Charles F. Shoop, B. S., Assistant Professor of Experimental Engineering

1. Strength of Materials — Assistant Professor Shoop
Two credits (four laboratory hours per week) — First semester
Open to students taking mechanics 9. Required of juniors in E. M. and Met. E. courses.
Laboratory work, investigating the strength and physical qualities of iron, steel, brass, copper, belting, chains, beams, brick, and stone.

2. Steam Laboratory — Assistant Professor Shoop
Two credits (four laboratory hours per week) — Second semester
Open to students completing mechanical engineering 18. Required of juniors in E. M. and Met. E. courses.
Exercises in valve setting, indicator practice, calibration of steam gauges, efficiency of screws and hoists.

5. Experimental Laboratory — Professor Kavanaugh
Two credits (four laboratory hours per week) — Second semester
Open to students completing 2. Required of seniors in E. M. and Met. E. courses.
Hydraulic measurements. Calibration of weirs, nozzles, meters, and other hydraulic apparatus, calorimetry; tests of pumps, engines, and boilers.

FRENCH AND SPANISH

CHARLES W. BENTON, M. A., Litt. D., Professor, Head of Department of Romance Languages
CHARLES M. ANDRIST, M. L., Professor
JULIUS T. FRELIN, B. A., Assistant Professor
CARL M. MELOM, M. A., Instructor
HOMER A. DESMARAIS, B. A., Scholar

FRENCH

1. BEGINNING — PROFESSOR ANDRIST, ASSISTANT PROFESSOR FRELIN, AND MR. DESMARAIS
Six credits (three hours per week) — Both semesters
Open to first-year students in E. M. (Geology) course.
Fraser and Squair's *French Grammar and Reader;* modern texts.

2. INTERMEDIATE — PROFESSOR ANDRIST
Six credits (three hours per week) — Both semesters
Open to students completing course 1.
Modern texts will be read, including some of the works of Coppee, Merimee, Daudet, Scribe, etc.

3. ADVANCED GRAMMAR AND COMPOSITION — PROFESSOR ANDRIST
Six credits (three hours per week) — Both semesters
Open to students in E. M. (Geology) course who enter with two years of French.
Readings from modern authors, including selections from Coppee, Feuillet, and Sandeau.

5. THE CLASSICAL PERIOD OF FRENCH LITERATURE — PROFESSOR BENTON
Six credits (three hours per week) — Both semesters
Open to students completing courses 2 or 3.
The reading of works and selections produced during the classical period of French literature, and conversations in French concerning the same. The works of Corneille, Racine, Moliere, La Fontaine, etc. Compositions.

SPANISH

11. BEGINNING — MR. MELOM
Six credits (three hours per week) — Both semesters
Required of first-year students in E. M. and Met. E. courses.
Monsanto and Languellier, *Spanish Course-Josselyn;* Worman, *First Spanish Book;* Bransby, *Spanish Reader.*

GERMAN

JOHN G. MOORE, B. A., Professor, Head of Department of German
HANS JUERGENSEN, M. A., Assistant Professor
OSCAR BURKHARD, M. A., Assistant Professor
RICHARD WISCHKAEMPER, M. A., Instructor

1. Beginning — Assistant Professors Juergensen and Burkhard, Mr. Wischkaemper
Six credits (three hours per week) — Both semesters
Open to first-year students in E. M. (Geology) course.
Pronunciation, grammar, conversation and composition; selected reading in easy prose and verse.

3b. Scientific Intermediate — Assistant Professors Juergensen and Burkhard, Mr. Wischkaemper
Six credits (three hours per week) — Both semesters
Open to students completing course 1.
This course is arranged to meet the peculiar needs of students of the School of Mines.
Text: Merckel's *Bilder aus der Ingenieurtechnik.*

4. Prose and Poetry — Professor Moore, Assistant Professors Juergensen and Burkhard, Mr. Wischkaemper
Six credits (three hours per week) — Both semesters
Open to first-year students in E. M. (Geology) course who enter with two years of German.
Meissner's *Aus deutschen Landen;* Goethe's *Gedichte;* Heine's *Buch der Lieder.* Geography, history, and legend. Review of German grammar throughout the year. This course may be supplemented.

7. Advanced Scientific Reading — Assistant Professors Juergensen and Burkhard
Six credits (three hours per week) — Both semesters
Open to students who have taken course 3 or 4. Reading of scientific monographs and periodicals.

MECHANICS AND MATHEMATICS

Elting H. Comstock, M. S., Professor of Mechanics and Mathematics
Edwin M. Lambert, M. E., Assistant Professor of Mechanics and Mathematics

1. Algebra — Assistant Professor Lambert
Four credits (four recitations per week) — First semester
Required of first-year students, five-year courses.
Review of elementary algebra, equations with one, two or more unknown quantities, inequalities, involution and evolution, theory of exponents, surds, quadratic equations, both numerical and literal, equations with one or more unknown quantities that can be solved by means of quadratic equations, progressions.

2. Solid Geometry and Mensuration — Assistant Professor Lambert
Three credits (three recitations per week) — Second semester
Required of first-year students, five-year courses.
Demonstrations of most important theorems, volumes, approximate volumes, prismoidal formula, etc.

3. Computation and Mensuration — Professor Comstock
Three credits (three recitations per week) — First semester
Required of first-year students, five-year E. M. and Met. E. courses.
Approximate computation, graphs and graphical computation, logarithms and logarithmic computation, areas and approximations of areas.

4. Elementary Mine Accounting — Professor Comstock
Three credits (three lectures and recitations per week) — Second semester
Required of first-year students, five-year E. M. and Met. E. courses.
Elementary accounting in general, applications to mine accounts; primary records, labor, supply, mine and mill products, and fund sheets; secondary records, invoice, labor and supply, mine and mill cost sheets, trial balance, etc.

5. Algebra and Trigonometry — Assistant Professor Lambert
Five credits (five recitations per week) — First semester
Required of freshmen.
Functions and functional notation, factors and roots of general quadratics, factor and remainder theorems, factors and values of functions, determinants, development of functions and undetermined coefficients, derived functions, theory of equations, permutations and combinations; trigonometric ratios, right triangles, general definitions of trigonometric functions, analytic relations, addition formulas, etc.

6. Trigonometry and Analytic Geometry — Assistant Professor Lambert
Five credits (five recitations per week) — Second semester
Open to students completing 5. Required of freshmen.
Trigonometric equations, oblique triangles, spherical formulas and solution of spherical triangles; systems of co-ordinates, loci, straight line, transformations, equations of conics, properties of conics.

7. Analytic Geometry and Calculus — Assistant Professor Lambert
Five credits (five recitations per week) — First semester
Open to students completing 6. Required of sophomores.
General equation of second degree, higher plane curves, co-ordinates in space, point, plane, straight line, quadric surfaces; nature of differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, elementary integration, expansion of functions, indeterminate forms, partial derivatives, change of variable.

8. Calculus — Assistant Professor Lambert
Five credits (five recitations per week) — Second semester
Open to students completing 7. Required of sophomores.
Applications continued, rational fractions, rationalization, formulas of reduction, multiple integration, various systems of co-ordinates, approximate integration, hyperbolic functions, some differential equations of mechanics; adjustments of observations.

9. Mechanics — Professor Comstock
Five credits (five recitations and lectures per week) — First semester
Open to students completing 8, and physics 3. Required of juniors.
Statics and dynamics, rectilinear, circular, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy; elementary mechanics of materials.

10. Strength and Resistance of Materials — Professor Comstock
Three credits (three recitations and lectures per week) — Second semester
Open to students completing 9. Required of juniors.
Mechanical and elastic properties of materials of construction; beams, shafts, columns, reinforced concrete, hollow cylinders and spheres, rollers, plates; theory of internal stress.

12. Engineering Construction — Professor Comstock
Three credits (one lecture, four drafting hours per week) — Second semester
Open to students completing 9. Required of juniors in E. M. and Met. E. courses.

Graphic statics, analytic and graphic resolution of stresses in framed structures, loads, stresses in mining structures, design of mining structures.

13. Hydraulics and Water Power — Professor Comstock
Five credits (five recitations and lectures per week) — First semester
Open to students completing 12. Required of seniors.

Laws of the equilibrium, pressure and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, number and type of units to install, speed control, power house equipment, transmission.

14. Power and Mine Plant Design — Professor Comstock
Three credits (six drafting hours per week) — Second semester
Open to students completing 13. Required of seniors in E. M. and Met. E. courses.

A study of power possibilities, costs, etc., and design of a power plant, surface equipment, and structures in connection with thesis work.

MECHANICAL ENGINEERING

John J. Flather, Ph. B., M. E., Professor of Mechanical Engineering
S. Carl Shipley, B. S., M. E., Assistant Professor of Machine Construction
William H. Richards, Instructor in Carpentry and Pattern Work
Edward Quigley, Instructor in Forge Work
Peter Peterson, Instructor in Foundry Practice

1. Carpentry — Mr. Richards
Four credits (six hours per week, six weeks) — First semester
Required of first-year students, five-year E. M. and Met. E. courses.
Wood working, use of tools; lathe and bench work. Patterns for moulding, core boxes, flasks. Lectures and practice.

2. Blacksmithing — Assistant Professor Shipley and Mr. Quigley
Two credits (six hours per week, twelve weeks) — First semester
Required of first-year students, five-year E. M. and Met. E. courses.
Use of tools, forging, welding, tool dressing, tempering. Lectures and practice.

3. Foundry Practice — Mr. Peterson
Three credits (six hours per week) — Second semester
Required of first-year students, five-year E. M. and Met. E. courses.
Moulding, casting, mixing metals, brass work, and core making.
Shop practice, recitations, and lectures.

18. Steam Engine — Professor Flather
Two credits (two lectures per week) — First semester
Open to students taking mechanics 9. Required of juniors in E. M. and Met. E. courses.

Mechanics of the steam engine. Work in cylinder; effect of reciprocating parts; steam distribution. Mechanism of steam engines. A study of the details of modern steam engines. Valve and valve gears. A study of the slide valve, link motions and other reversing gear; automatic cut-off gears and the Zeuner diagrams. The steam engine indicator. Principles and operation of the instruments, indicator riggings, indicator cards, compounding.

METALLURGY

WILLIAM R. APPLEBY, M. A., Professor of Metallurgy
PETER CHRISTIANSON, B. S., E. M., Professor of Metallurgy
LEVI B. PEASE, M. S., Professor of Metallurgy

1. ASSAYING — PROFESSOR APPLEBY AND ASSISTANTS
Eight credits (four lectures and eight laboratory hours per week) Second semester
Open to students completing mineralogy 1. Required of freshmen in E. M. and Met. E. courses.
Determination of values of ores, metallurgical products and bullion.

2. ORE TESTING — PROFESSOR APPLEBY AND ASSISTANTS
Six credits (two lectures and eight laboratory hours per week) First semester
Open to students completing 1 and mining 5. Required of seniors in E. M. and Met. E. courses.
Determination of methods of ore treatment, stamping, concentration, cyanidation, roasting, chlorination, lixiviation, and amalgamation.

3. GENERAL METALLURGY AND METALLURGY OF IRON — PROFESSOR CHRISTIANSON
Three credits (three lectures per week) First semester
Open to students completing 1. Required of sophomores in E. M. and Met. E. courses.
Including the subjects of combustion, fuels, refractory materials, and furnaces. Lectures and recitations on metallurgy of iron.

4. METALLURGY OF WROUGHT IRON AND STEEL — PROFESSOR CHRISTIANSON
Three credits (three lectures per week) Second semester
Open to students completing 3. Required of sophomores in E. M. and Met. E. courses.
Consideration of the principles of manufacture, details of plant construction, and chemical and physical phenomena. Metallography.

5. METALLURGY OF THE BASE METALS — PROFESSOR PEASE
Four credits (four lectures per week) First semester
Open to students completing 4. Required of juniors in E. M. and Met. E. courses.
Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining methods.

6. METALLURGY OF THE PRECIOUS METALS — PROFESSOR PEASE
Four credits (four lectures per week) Second semester
Open to students completing 5. Required of juniors in E. M. and Met. E. courses.
Gold, silver, and platinum. Methods and principles of cyanidation, chlorination, amalgamation, and lixiviation as applied to the treatment of the above.

7. Electro-Metallurgy — Professor Christianson
Three credits (three lectures per week) — Second semester
Open to students completing 6. Required of seniors in Met. E. course.
This course considers the treatment of ores by electricity, as well as electrolytic separation and refining of metals.

8. Field Work in Metallurgy — Professor Appleby and Assistants
Two credits (eight hours per day in field for seven days.) — June following second semester
Open to students completing 6. Required of juniors.
Study of metallurgical operations at smelters and mills. Detailed report is required covering plants visited.

9. Thesis and Specifications — Professors Appleby and Comstock
Four credits (four hours, conference and laboratory) — Second semester
Open to students completing 8. Required of seniors in Met. E. course.
Detailed investigations of ore treatment, with report including designs and specifications for suitable plants.

MINING ENGINEERING

Charles E. van Barneveld, B. A., Sc., E. M., Professor of Mining Engineering
Edward P. McCarty, E. M., Professor of Mining
Merton S. Kingston, E. M., Assistant Professor of Mining

1. Mining — Professor McCarty
Four credits (four lectures per week) — Second semester
Open to sophomores in regular standing. Required of sophomores.
Explosives, blasting, air compressors, and quarrying.

2. Mining — Professor van Barneveld
Ten credits (five lectures per week) — Both semesters
Open to those who have completed 1. Required of juniors.
Mode of occurrence of ore bodies; prospecting, shaft-sinking, tunneling, drifting, stoping, timbering. Methods of metal mining. Methods of coal mining. Hydraulic mining.

3. Mine Surveying — Professor McCarty and Assistant Professor Kingston
Five credits (five lectures per week) — First semester
Open to those who have completed mathematics 8 and mining 1.
Required of juniors.
Computation, platting, and problems with special reference to mine surveying.

4. Mining and Mining Engineering — Professor van Barneveld
Ten credits (five lectures per week) — Both semesters
Open to those who have completed mining 2 and 3. Required of seniors.
Mine management. The examination of a mining property. Sampling ore reserves, etc. Mine accounts. Mine accidents. Mining law. Mining machinery, underground transportation, hoisting, pumping, and ventilation. Electricity applied to mining.

5. Ore Dressing — Professor McCarty
Five credits (five lectures per week) — Second semester
Open to those having completed sophomore work. Required of juniors.
Mechanical preparation of ore for the markets, for metallurgical treatment, etc.

6. Designs and Specifications — Professors van Barneveld and Comstock
Four credits (eight drafting hours per week) — Second semester
Open only to seniors in regular standing. Required of seniors in E. M. course.
Designs of mine cars, skips, head-frames, etc., in connection with thesis work.

7. Mine Mapping — Assistant Professor Kingston
Three credits (six drafting hours per week) — Second semester
Open to those who have completed 3. Required of juniors.

8. Field Work — Professor van Barneveld and Assistants
Eight credits (eight hours a day for six weeks) — Second semester
Open to those who have completed mining 3. Required of juniors.
Practice in plane surveying during month of May. Practice in underground mine surveying during first two weeks of June.

9. Practical Mining — Professor van Barneveld and Assistants
Eight credits (eight hours per day for six weeks) — Summer vacation
Open to those who have completed 7 and 8. Required of juniors.
Study of mining operations. Mine plant and equipment and practical mining work at a mine to be selected by department during months of July and August.

10. Thesis — Professor van Barneveld and Assistants
Two and four credits (two and four-hour conferences) — Both semesters
Open only to seniors in regular standing. Required of seniors in E. M. course.
Conference with individual students. This work is based upon a review of the preceding technical work and field work.

MINERALOGY AND GEOLOGY

Christopher W. Hall, M. A., Professor of Mineralogy and Geology
Frank F. Grout, M. S., Assistant Professor of Mineralogy and Geology
Oliver Bowles, M. A., Instructor in Mineralogy and Geology
Edgar K. Soper, A. B., Instructor in Economic Geology

1. General Mineralogy — Assistant Professor Grout
Six credits (four lectures, four laboratory hours per week) — First semester
Required of freshmen.
The physical and chemical characters of minerals, a study of the native elements and the ores of the common metals; the occurrence and association of economic minerals.
Descriptive mineralogy and classification; rock-forming minerals; genetic relationship and distribution.
Laboratory work consists of tests illustrating the range of minerals and the application of chemical and blowpipe analyses to the determination of species; introduction to the methods of quantitative blowpipe analysis; special topics; reference reading and discussions.

2. Physical Mineralogy — Assistant Professor Grout
Three credits (two lectures, two laboratory hours per week) Second semester
Open to students completing 1. Required of freshmen.
An introduction to crystallography; physical characters of greatest service in rapid determination. Hand specimen practice preparatory to rock study.

3. Elements of Geology — Mr. Soper
Three credits (three lectures per week) Second semester
Required of sophomores.
A course designed to acquaint the student with the fundamental principles of geology preparatory to the study of mining.
1. Geodynamics, discussing the atmosphere, water, vulcanism, plants and animals as geologic agents. 2. Structural geology, explaining stratification, displacements, dislocations, fractures, and mineral veins. 3. Sight identification of common rocks. 4. An elementary discussion of the formation of ore deposits. Local excursions are required. Scott's Introduction; Spurr's Mining Geology.

3(a). Field Work — Mr. Soper
One credit (first two weeks in June)
Required of sophomores.
A two-week excursion to the iron ranges for practice in field methods, such as tracing contacts, working out structures, and constructing and interpreting geologic maps.

4. Historical and Economic Geology — Professor Hall and Mr. Soper
Three credits (three lectures a week) First semester
Required of juniors.
1. The application of geodynamics to rock structure, folding, deformation and metamorphism. The application of these principles to the formation and deposition of mineral deposits. A study of the characteristic features of the successive ages of geologic history.
2. A study of the distribution, occurrence, and uses of the non-metallic minerals, including a discussion of prospecting for these minerals and the usual methods of geological mapping. Lectures, recitations, and reading with local excursions to neighboring quarries.

9. Elements of Rock Study — Mr. Bowles
Two credits (four laboratory hours per week) First semester
Open to students completing 3. Required of juniors.
Structures, textures, mineral and chemical composition of rocks.
A practical study of rock types, with laboratory and field practice.
A study of their origin, occurrence, variation, and alteration, with view to accurate description. Introduction to the use of the microscope. Kemp's Hand Book of Rocks, and reference reading.

10. Petrography — Mr. Bowles
Two credits (four laboratory hours per week) Second semester
Open to students completing 9. Required of juniors.
The application of optical study of minerals to the description of crystalline rocks. Rock structures as seen with microscope. Alteration of rocks. The stratigraphic relation of rocks, and an examination of some Minnesota groups of crystalline rocks. Preparation of material for microscopic study. Luquer's Minerals in Rock Sections, and reference readings

12. Ore Deposits — Mr. Soper
Four credits (four lectures per week) — First semester
Open to students completing 10. Required of seniors.

History of mineral discovery and development in the Americas; a discussion of the origin and distribution of ore deposits, embracing the chemical processes involved in their formation and subsequent alterations. A description of the geology and mineralogy of ore bodies, particularly those yielding gold, silver, copper, iron, lead, and zinc. Kemp's Ore Deposits.

13. Special Problems — Mr. Soper
Two credits (four laboratory hours per week) — Second semester
Open to students completing 12. Required of seniors in E. M. and E. M. (Geology) courses.

The investigation of problems, involving the field and laboratory work of some particular formation and reading incident to the study of the material collected. The methods of systematically recording and interpreting geological and mineralogical data as observed in the field; keeping of notebook, preparation of geological maps, profiles, and sections will be taught.

PHYSICS

John Zeleny, Ph. D., Professor of Physics
William F. Holman, Ph. D., Instructor in Physics
L. W. McKeehan, B. S., Instructor in Physics

1. General Physics — Professor John Zeleny and Mr. Holman
Three credits (three hours per week) — First semester
Open to students who have completed mathematics 6. Required of sophomores.

Mechanics of solids and fluids, heat and sound. This is the first part of an elementary course in physics, designed for those who do not intend to pursue the subject longer than one year. The course is experimental rather than mathematical and gives the student a general knowledge of the fundamental principles of the subject. There will be one experimental lecture and two recitations each week.

2. General Laboratory Practice — Mr. McKeehan
One credit (two hours per week) — First semester
Open to students taking course 1. Required of sophomores.

Physical measurements in the mechanics of solids and fluids, and in heat and sound, giving the student a knowledge of experimental methods.

3. General Physics — Professor John Zeleny and Mr. Holman
Three credits (three hours per week) — Second semester
Open to students who have completed course 1. Required of sophomores.

Light, electricity and magnetism. This is the second part of the elementary course begun under course 1. The treatment is experimental and the fundamental principles of the subjects, including those of radioactivity, ionization, X radiation, and the electrical constitution of matter, are discussed and illustrated. There will be one experimental lecture and two recitations each week.

General Laboratory Practice — Mr. McKeehan
One credit (two hours per week) — Second semester
Open to students taking course 3. Required of sophomores.

Physical measurements in light, electricity and magnetism, giving the student a knowledge of experimental methods.

RHETORIC AND PUBLIC SPEAKING

JOSEPH M. THOMAS, Ph. D., Professor, Head of Department of Rhetoric and Public Speaking
CHARLES W. NICHOLS, M. A., Instructor in Rhetoric

15. RHETORIC AND COMPOSITION — MR. NICHOLS
Eight credits (four hours per week) — Both semesters
Required of first-year students.

This course is planned with special reference to the needs of students of the School of Mines. Two hours a week will be given to the study of English composition, and two hours to the study of a general survey of English literature. Essays will be required every week.

While in the study of literature one object will be the general broadening of the mind by an acquaintance with the masterpieces of English prose and poetry, especial attention will be given to the work of those writers who have handled scientific subjects with clearness and power.

Students

SENIORS—27

Abbott, Theodore S., St. Paul
Anderson, Joseph, Florence
Anderson, Walter C., Hopkins
Bailey, Paul T., Minneapolis
Baker, Emory P., Minneapolis
Beck, Chas. S., Lewiston
Borgeson, Anshelm C., Minneapolis
Burgess, Robert J., Minneapolis
Crouse, Charles Stevens, Minneapolis
Drake, George M., Madelia
Ekloff, Victor E., Cokato
Elliot, Jay R., Minneapolis
Fixen, Victor L., Minneapolis
Fosness, Arthur W., Lakefield
Hill, Arthur S., Minneapolis
Hurley, John J., Pine City
Jahn, William F., Winona
Kingsley, Neil S., Minneapolis
Lindholm, Milton S., Ortonville
McCullough, Ervin W., St. Paul
Rahilly, Harold J., Minneapolis
*Swartz, Samuel G., St. Paul
Tetlie, John R., Staples
Walker, E. Harold, Minneapolis
Walters, Chas. W., St. Paul
Wehr, Arthur J., Lake Shore
Whitson, Lloyd R., Fergus Falls

JUNIORS—26

Bjorge, Guy N., Duluth
Cohen, Julius M., St. Paul
Coventry, Edward D., Duluth
Dickson, Robert H., Minneapolis
Hagstrom, Leonard J., Minneapolis
Harrington, Geo. L., Langdon
Hayward, Josiah E., St. Cloud
Hewitt, Ezra A., Minneapolis
Kennedy, Charles T., Eau Claire, Wis.
Knox, Lafayette F., Grand Rapids
Kremer, Edward G., Grand Rapids
Lea, John, Minneapolis
Lewis, John W., Minneapolis
McAdams, Howard R., Minneapolis
Martin, Lynn U., Grand Meadow
O'Brien, J. Chas., St. Paul
Olson, Walter S., St. Paul
Perry, Joe B., Minneapolis
Prouty, Roswell W., St. Paul
Quinn, Max F., Spokane, Wash.
Stevens, Howard E., Stillwater
Taylor, W. L., Dundas
Victor, Albin F., Lindstrom
Wallinder, Arthur, Duluth
Walter, Rollie B., Delano
Woodis, Clark N., Amboy

SOPHOMORES—25

Anderson, Arthur P., Minneapolis
Bentley, Frank C., Albert Lea
Coady, Leo J., Pattin, Maine
Ekstrom, Alex. J., Hibbing
Ely, Robert H., Duluth
Fields, Howard H., St. Paul
Hammond, Arthur H., Minneapolis
Hanson, J. Bernard, Minneapolis
Harvey, Harry J., Duluth
Haugan, Albert C., Hanska
Hondrum, Olaf, Bemidji
Ladd, Greeley, Minneapolis
Larson, John Ed., Minneapolis
McCormack, Clyde P., Minneapolis
Michie, Roy G., Montevideo
Nissen, Arvid E., Minneapolis

*Died January 5, 1911

Nordale, Carl E., Minneapolis
Ofsthun, Norman H., Glenwood
Paddack, Donald, Duluth
Quinlan, Howard, St. Paul
Robertson, John H., St. Paul
Schultze, Max F., Walker
Smith, Ralph W., St. Paul
Walker, Charles A., Brainerd
Williams, J. H., Ely

FRESHMEN—12

Amidon, Richard G., Minneapolis
Benton, Sam, Bisbee, Ariz.
Bierman, Alfred, Litchfield
Chatfield, William E., Minneapolis
Larson, Ernest L., Akeley
Potter, Orrin W., St. Paul
Ravicz, Louis, Minneapolis
Richard, Charles L., Stillwater
Speaker, Raymond, Wayzata
Van Cleve, R. H., Minneapolis
Vorck, Charles R., St. Paul
Williams, Paul S., Lake Benton

FIRST-YEAR CLASS—15

Buresh, Charles E., Lakefield
Butler, William V., Little Falls
Collins, Leon T., Pine Island
Davidson, Harry T., Minneapolis
Dopp, Lawrence, Ashland, Wis.
Harmon, Sidney E., St. Paul
Heilig, Louis S., Minneapolis
Johnson, Fred C., Willmar
Kerr, Charles D., St. Paul
Lee, Martinus, Minneapolis
Montgomery, Daniel, Worthington
Nelson, Elmer C., Little Falls
Nord, Harry H., Ashland, Wis.
Scott, William L., St. Paul
Weinhagen, Carl, St. Paul


THE UNIVERSITY
OF MINNESOTA
OMNIBUS
COMMUNE VINCULUM
ARTIBUS

The University of Minnesota

THE SCHOOL OF MINES

1912-1913

BULLETIN OF THE UNIVERSITY OF MINNESOTA
VOL. XV, NO. 7. JUNE 1912

Entered at the Post Office
in Minneapolis as second-class matter
MINNEAPOLIS, MINN.

The University catalogues are published by authority of the Board of Regents, as a regular series of bulletins. One bulletin for each college and one for the Summer Session is published every year and in addition a bulletin of general information outlining the entrance requirements of all colleges of the University, and embodying such items as University equipment, organizations and publications, expenses of students, loan and trust funds, scholarships, prizes, etc. Bulletins will be sent gratuitously, postage paid, to all persons who apply for them. In calling for bulletins, the college or school of the University concerning which information is desired should be stated. Address,

THE REGISTRAR,
The University of Minnesota,
Minneapolis, Minnesota

OF THE
1931
IS.


COMO-HARRIET CAR LINE
4TH ST. S.E.
12TH. AVE.
13TH. AVE.
14TH. AVE.
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16TH. AVE.
17TH. AVE.
18TH. AVE.
19TH. AVE.
UNIVERSITY AVE. S.E.
11 AVE. S.E.
SANFORD HALL
GREEN HOUSE
Y.M.C.A.
FOLWELL HALL
ARMORY
NORTHROP FIELD
GREAT NORTHERN RY.
TENNIS COURTS
LAW.
PHYSICS
PILLSBURY HALL
MINES.
SHEVLIN HALL.
MECH. ARTS
CHEMISTRY.
ELECTRICAL BUILDING
ORE.
LIBRARY.
OBSERVATORY
HEATING PLANT.
MEDICAL SCIENCE
MECHANICAL ENGINEERING
BERGON ST. S.E.
MODEL SCHOOL BUILDING
PUBLIC HEALTH AND PATHOLOGY.
MEDICAL CHEMISTRY
CAMPUS CLUB
MISSISSIPPI RIVER.
OLD ANATOMY
MILLARD HALL
EXPERIMENTAL ENGINEERING BUILDING
WASHINGTON AVE. S.E.
WALNUT ST.
HARVARD ST.
MAIN ENGINEERING BUILDING
NEW MILLARD HALL
UNION ST.
DELAWARE ST.
NORTHERN PACIFIC RY.
PROSPECT ST.
NEW ANATOMY
NURSES HOME
ART SCHOOL
MINNEAPOLIS - ST. PAUL INTERURBAN
STATE ST.
CHURCH ST.
ESSEX ST.
ANATOMY
PLEASANT ST.
ELLIOT MEMORIAL HOSPITAL
FULTON ST.
RIVER ROAD - EAST.
RELATIVE POSITION OF UNIVERSITY OF MINNESOTA AND AGRICULTURAL COLLEGE
COMO-HARRIET CAR LINE TO AGRICULTURAL COLLEGE. GET OFF AT CARTER AVE.
MAP OF THE CAMPUS
UNIVERSITY OF MINNESOTA
Scale 1 inch = 200 feet.

The University of Minnesota

THE SCHOOL OF MINES

1912-1913

BULLETIN OF THE UNIVERSITY OF MINNESOTA
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MINNEAPOLIS, MINN.

1912

JULY

Su	Mo	Tu	W	Th	Fr	Sa
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14	15	16	17	18	19	20
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AUGUST

Su	Mo	Tu	W	Th	Fr	Sa
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SEPTEMBER

Su	Mo	Tu	W	Th	Fr	Sa
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OCTOBER

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DECEMBER

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1913

JANUARY

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JULY

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AUGUST

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SEPTEMBER

Su	Mo	Tu	W	Th	Fr	Sa
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OCTOBER

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NOVEMBER

Su	Mo	Tu	W	Th	Fr	Sa
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23	24	25	26	27	28	29
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DECEMBER

Su	Mo	Tu	W	Th	Fr	Sa
	1	2	3	4	5	6
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14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	..	..	..

UNIVERSITY CALENDAR

1912-1913

The University year covers a period of thirty-eight weeks, beginning on the second Tuesday in September. Commencement Day is always the second Thursday in June.

1912			
September	3	Tuesday	Registration closes except for new students
September	3-10	Week	Fees payable except for new students
September	10-16	Week	Entrance examinations, registration of new students, and payment of fees
September	11-17	Week	Military encampment of cadets
September	18	Wednesday	First semester begins
November	27	Wednesday	Thanksgiving recess begins 6:00 p. m.
December	2	Monday	Thanksgiving recess ends 8:00 a. m.
December	20	Friday	Christmas vacation begins 6:00 p. m.
1913			
January	7	Tuesday	Christmas vacation ends 8:00 a. m.
January	21	Tuesday	Registration for second semester closes
January	27	Monday	Final examinations begin
January	28	Tuesday	Payment of fees for second semester closes
February	5	Wednesday	Second semester begins
February	12	Wednesday	Lincoln's Birthday: a holiday
February	13	Thursday	First semester class reports due
February	22	Saturday	Washington's Birthday: a holiday
March	19	Wednesday	Easter recess begins 6:00 p. m.
March	27	Thursday	Easter recess ends 8:00 a. m.
May	30	Friday	Decoration Day: a holiday
June	2	Monday	Final examinations begin
June	7	Saturday	Second semester closes
June	8	Sunday	Baccalaureate service
June	9	Monday	Senior class day exercises
June	11	Wednesday	Alumni Day
June	12	Thursday	Forty-first Annual Commencement
June	13	Friday	Summer vacation begins

The University year for 1913-14 will begin Tuesday, September 9.

Program of Entrance Examinations 1912-13

When entrance examinations are required this schedule will be followed:

Tuesday, Sept. 10	9 a. m.	Astronomy, Botany, Geology, Chemistry, Physiography, Zoology
	2 p. m.	American Government, History, Physics, Economics, Commercial Geography
Wednesday, Sept. 11	9 a. m.	English
	2 p. m.	German, French, Latin, Scandinavian
Thursday, Sept. 12	9 a. m.	Elementary Algebra
	2 p. m.	Higher Algebra
Friday, Sept. 13	9 a. m.	Plane Geometry
	2 p. m.	Solid Geometry
Thursday, June 5, 1913	9 a. m.	Elementary Algebra
	2 p. m.	Higher Algebra
Friday, June 6, 1913	9 a. m.	Plane Geometry
	2 p. m.	Solid Geometry

All candidates for examinations should report at the scheduled time in Room 205, Library Building, except in the case of Mathematics.

Examinations in Mathematics are held in Room 24, School of Mines Building.

Program of Supplementary Examinations

Tuesday, Sept. 10	9-12 a. m.	Mechanics and Mathematics
	2-5 p. m.	Mining Engineering Subjects
Wednesday, Sept. 11	9-12 a. m.	Chemistry
	2-5 p. m.	Drawing and Descriptive Geometry
	2-5 p. m.	Mechanical Engineering Subjects
Thursday, Sept. 12	9-12 a. m.	Metallurgical Subjects
	2-5 p. m.	Physics
Friday, Sept. 13	9-12 a. m.	Electrical Engineering Subjects
	2-5 p. m.	Geology and Mineralogy

THE UNIVERSITY

THE UNIVERSITY OF MINNESOTA comprises the following named schools, colleges, and departments:

THE COLLEGE OF SCIENCE, LITERATURE, AND THE ARTS

THE COLLEGE OF ENGINEERING AND THE MECHANIC ARTS

THE DEPARTMENT OF AGRICULTURE, including—

- THE COLLEGE OF AGRICULTURE
- THE COLLEGE OF FORESTRY, including—
  - FOREST EXPERIMENT STATIONS AT ITASCA AND CLOQUET
- THE SCHOOL OF AGRICULTURE, including—
  - THE DAIRY SCHOOL
  - THE SHORT COURSE FOR FARMERS
  - TEACHERS' SUMMER TRAINING SCHOOL
  - THE SCHOOL OF TRACTION ENGINEERING
- THE SCHOOL OF AGRICULTURE, CROOKSTON
- THE SCHOOL OF AGRICULTURE, MORRIS
- THE EXPERIMENT STATIONS, including—
  - THE MAIN STATION AT ST. ANTHONY PARK
  - THE SUB-STATION AT CROOKSTON
  - THE SUB-STATION AT GRAND RAPIDS
  - THE SUB-STATION AT DULUTH
  - THE SUB-STATION AT WASECA
  - THE SUB-STATION AT ZUMBRA HEIGHTS
- AGRICULTURAL EXTENSION
- BUREAU OF RESEARCH IN AGRICULTURAL ECONOMICS

THE LAW SCHOOL

THE COLLEGE OF MEDICINE AND SURGERY, including—

- THE SCHOOL FOR NURSES

THE COLLEGE OF DENTISTRY

THE COLLEGE OF PHARMACY

THE SCHOOL OF MINES, including—

- MINNESOTA SCHOOL OF MINES EXPERIMENT STATION

THE SCHOOL OF ANALYTICAL AND APPLIED CHEMISTRY

THE COLLEGE OF EDUCATION

THE GRADUATE SCHOOL

THE GEOLOGICAL AND NATURAL HISTORY SURVEY

THE BOARD OF REGENTS

The Hon. JOHN LIND, Minneapolis, President of the Board - - 1914
GEORGE EDGAR VINCENT, Ph.D., LL.D., Minneapolis - - *Ex-Officio*
The President of the University
The Hon. ADOLPH O. EBERHART, Mankato - - - - - *Ex-Officio*
The Governor of the State
The Hon. C. G. SCHULZ, St. Paul - - - - - - - *Ex-Officio*
The State Superintendent of Public Instruction
The Hon. W. J. MAYO, Rochester - - - - - - - - 1913
The Hon. MILTON M. WILLIAMS, Little Falls - - - - - 1913
The Hon. HENRY B. HOVLAND, Duluth - - - - - - - 1914
The Hon. A. E. RICE, Willmar - - - - - - - - 1915
The Hon. CHARLES L. SOMMERS, St. Paul - - - - - - 1915
The Hon. B. F. NELSON, Minneapolis - - - - - - - 1916
The Hon. PIERCE BUTLER, St. Paul - - - - - - - 1916
The Hon. CHARLES A. SMITH, Minneapolis - - - - - - 1916

EXECUTIVE OFFICERS

GEORGE EDGAR VINCENT, Ph.D., LL.D., President
ERNEST B. PIERCE, B.A., Registrar
GEORGE H. HAYES, University Comptroller and Secretary of the Board of Regents
JAMES T. GEROULD, B.A., Librarian
JOHN F. DOWNEY, M.A., C.E., Dean of the College of Science, Literature, and the Arts
FRANCIS C. SHENEHON, C.E., Dean of the College of Engineering and Mechanic Arts
ALBERT F. WOODS, M.A., Dean and Director of the Department of Agriculture
WILLIAM R. VANCE, Ph.D., LL.B., Dean of the Law School
FRANK FAIRCHILD WESBROOK, M.A., M.D., C.M., Dean of the College of Medicine and Surgery
ALFRED OWRE, B.A., M.D., C.M., D.M.D., Dean of the College of Dentistry
FREDERICK J. WULLING, Phm.D., LL.M., Dean of the College of Pharmacy
WILLIAM R. APPLEBY, M.A., Dean of the School of Mines
GEORGE B. FRANKFORTER, M.A., Ph.D., Dean of the School of Chemistry
GEORGE F. JAMES, Ph.D., Dean of the College of Education
HENRY T. EDDY, C.E., Ph.D., LL.D., Dean of the Graduate School
ADA L. COMSTOCK, M.A., Dean of Women

THE SCHOOL OF MINES

FACULTY

George Edgar Vincent, Ph.D., LL.D., President 1005 5th St. S. E.
Cyrus Northrop, LL.D., President Emeritus 519 10th Ave. S. E.
William R. Appleby, M.A., Dean and Professor of Metallurgy 911 5th St. S. E.
Charles E. van Barneveld, B.A.Sc., E.M., Professor of Mining Engineering 2110 Aldrich Ave. S.
Charles W. Benton, Litt.D., Professor of Romance Languages 516 9th Ave. S. E.
Peter Christianson, B.S., E.M., Professor of Metallurgy 208 Beacon St. S. E.
Elting H. Comstock, M.S., Professor of Mechanics and Mathematics 1416 7th St. S. E.
William H. Emmons, Ph.D., Professor of Mineralogy and Geology
John J. Flather, Ph.B., M.M.E., Professor of Mechanical Engineering 315 11th Ave. S. E.
George B. Frankforter, Ph.D., Professor of Chemistry 525 E. River Road
William H. Kavanaugh, M.E., Professor of Experimental Engineering 118 State St. S. E.
William H. Kirchner, B.S., Professor of Drawing and Descriptive Geometry 217 Beacon St. S. E.
Edward P. McCarty, E.M., Professor of Mining 428 8th St. S.
John G. Moore, B.A., Professor of German 2810 University Ave. S. E.
Levi B. Pease, M.S., Professor of Metallurgy 1070 16th Ave. S. E.
George D. Shepardson, M.A., M.E., Professor of Electrical Engineering 717 E. River Road
Charles F. Sidener, B.S., Professor of Chemistry 1320 5th St. S. E.
Joseph M. Thomas, Ph.D., Professor of Rhetoric 623 14th Ave. S. E.
John Zeleny, Ph.D., Professor of Physics 712 10th Ave. S. E.
Francis C. Frary, Ph.D., Assistant Professor of Chemistry 1307 6th St. S. E.
Jules T. Frelin, B.A., Assistant Professor of Romance Languages 112 Church St. S. E.
Frank F. Grout, M.S., Assistant Professor of Geology and Mineralogy 1202 7th St. S. E.

MERTON S. KINGSTON, E.M., Assistant Professor of Mining
1206 7th St. S. E.

EDWIN M. LAMBERT, M.E., Assistant Professor of Mechanics and Mathematics

WILLIAM T. RYAN, E.E., Assistant Professor of Electrical Engineering
3228 4th St. S. E.

FREDERICK W. SARDESON, Ph.D., Assistant Professor of Paleontology
414 Harvard St. S. E.

S. CARL SHIPLEY, B.S., M.E., Assistant Professor of Machine Construction
1517 E. River Road

CHARLES F. SHOOP, B.S., Assistant Professor of Experimental Engineering
108 Beacon St. S. E.

INSTRUCTORS

OLIVER BOWLES, M.A., Instructor in Mineralogy and Geology
321 19th Ave. S. E.

PAUL H. M.-P. BRINTON, Instructor in Chemistry 608 13th Ave. S. E.

LILLIAN COHEN, M.S., Instructor in Chemistry 415 E. 14th St.

ROBERT W. FRENCH, B.S., Instructor in Drawing
1035 13th Ave. S. E.

ERVIN W. MCCULLOUGH, E.M., Instructor in Mining
90 Malcolm Ave. S. E.

FRANKLIN R. MCMILLAN, C.E., Instructor in Experimental Engineering
321 Oak St. S. E.

EDMUND NEWTON, E.M., Instructor in Metallurgy
1005 University Ave. S. E.

PETER E. PETERSON, Instructor in Foundry Practice
3709 Clinton Ave.

WARREN T. POWELL, M.A., Instructor in Rhetoric 517 Essex St. S. E.

EDWARD P. QUIGLEY, Instructor in Forge Work 2442 15th Ave. S.

WILLIAM H. RICHARDS, Instructor in Carpentry 1423 W. 27th St.

FRANK B. ROWLEY, B.S., M.E., Instructor in Drawing
414 Oak St. S. E.

JAMES COXE SANDERSON, Ph.D., Instructor in Physics
710 13th Ave. S. E.

JULIUS H. SANTO, E.M., Instructor in Mechanics and Mathematics
1406 7th St. S. E.

EDGAR K. SOPER, B.A., Instructor in Economic Geology
417 Union St. S. E.

WINIFRED GREGORY, Librarian

ADMISSION

The courses leading to the degrees of Engineer of Mines and Metallurgical Engineer may be completed in either four or five years. The course leading to the degree of Engineer of Mines (in Geology) may be completed in five years.

Students may enter the School of Mines without preparation in Higher Algebra and Solid Geometry. Such students must enter the five-year courses.

Students who enter the four-year courses with Higher Algebra and Solid Geometry must pass the entrance examinations in Mathematics given by the School. State High School Board certificates will be accepted for all subjects except Mathematics.

It is recommended that students who come poorly prepared in Mathematics enter the five-year courses.

Examinations for admission in subjects other than Mathematics will be held at the beginning of the year. Examinations in Mathematics are held in June and September. See calendar and program of examinations.

No senior will be registered for first semester's work after September 10, 1912.

No other students will be registered for the first semester's work after September 28, 1912, nor any student for the second semester's work after February 15, 1913.

All applicants should present themselves to the Dean of the School of Mines, Room 27, School of Mines Building, who will furnish them with application blanks and directions covering examinations and registration.

Women will not be admitted to any course offered in the School of Mines.

GENERAL REGULATIONS GOVERNING ADMISSION

I. Students will be admitted to the freshman class on passing the regular entrance examinations.

II. No student will be admitted if conditioned in more than three half-year subjects, or their equivalent. No conditions, however, in entrance Mathematics shall be allowed except upon special permission of the Department of Mathematics.

III. Graduates of any Minnesota State High School will be admitted to the five-year courses without examination, or to the four-year courses with examination in Mathematics, provided:

(1) That the school maintain a full four-year course of high school work.

(2) That the applicant present to the Registrar the principal's certificate showing the satisfactory completion of all studies required for admission to the desired University course.

IV. Graduates of Minnesota State High Schools who are deficient in not more than three half-year subjects or their equivalent, may be excused from entrance examinations in such subjects as the Enrollment Committee may decide upon; such candidates should present themselves to the Committee not later than Tuesday of examination week.

V. Graduates of Minnesota State High Schools whose principal's certificate shows them to be deficient in more than three half-year subjects or their equivalent, even though they have made such additional preparation as they deem necessary, must take, nevertheless, the regular entrance examination in all subjects, as provided in Sections I and II, unless excused by vote of the Faculty; and persons wishing to present reasons for such excuse should report to the Enrollment Committee not later than Tuesday of examination week.

VI. Graduates of the Advanced Courses of Minnesota Normal Schools will be admitted upon the same terms as graduates of State High Schools.

VII. Any Minnesota High School or Academy not under supervision of the State High School Board, but requiring for graduation a four years' course, exclusive of the common school branches, conforming essentially in distribution of time to the entrance requirements of at least one of the University courses, will, upon application, be inspected by a committee, and, after favorable recommendation, may be accredited by the Faculty in all respects as are the State High Schools, provided:

(1) That the school be open to inspection at any time by the University.

(2) That it take such supplementary examinations as may be prescribed from time to time.

VIII. Graduates from schools in other states, whose diplomas admit to reputable colleges in the state in which the school is located, will be received subject to the regulations that apply to graduates of Minnesota State High Schools.

IX. Applicants coming from schools not included in any of the above classes must take the regular entrance examinations or present State High School Board certificates.

In all cases the Faculty reserves the right to require a student to take supplementary examinations if he does not sustain himself creditably in his course.

The Enrollment Committee will meet every day during the week commencing Tuesday, September 10th, in School of Mines Building, Room 27, at 9 o'clock, a. m.

REQUIREMENTS FOR ADMISSION TO THE FIVE-YEAR COURSES

The term *unit* means not less than five recitations of forty minutes each per week for a period of thirty-six weeks. In manual subjects and

kindred courses, it means the equivalent of ten recitation periods per week for thirty-six weeks.

Required Subjects:

English ..... *four units
Elementary Algebra ..... one unit
Plane Geometry ..... one unit
Electives ..... nine units

REQUIREMENTS FOR ADMISSION TO THE FOUR-YEAR COURSES

Required Subjects:

English ..... *four units
Elementary Algebra ..... one unit
Higher Algebra ..... one-half unit
Plane Geometry ..... one unit
Solid Geometry ..... one-half unit
Electives ..... eight units

Electives. (Eight units must be selected from this list for the four-year courses and nine units for the five-year courses.)

Latin
- Grammar, one unit
- Caesar, four books, one unit
- Cicero, six orations, one unit
- Virgil, six books, one unit

Greek
- Grammar, one unit
- Anabasis, four books, one unit

German
- Grammar, one unit
- Literature, one to three units

French
- Grammar, one unit
- Literature, one to three units

Spanish
- Grammar, one unit
- Literature, one unit

Scandinavian Languages
- Grammar, one unit
- Literature, one unit

History
- Ancient, to Charlemagne, one unit
- Modern, from Charlemagne, one unit
- English, one-half unit
- Senior American, one-half unit

*Three units will satisfy the English requirement when the applicant presents four units in one foreign language. In this case a sufficient number of electives must be presented to make a total of fifteen entrance units.

American Government, one-half unit
Elementary Economics, one-half unit
History of Commerce, one-half unit
Commercial Geography, one-half or one unit
Physics, one unit
Chemistry, one unit
Botany, one-half or one unit
Zoology, one-half or one unit
Astronomy, one-half unit
Geology, one-half unit
Physiography, one-half unit

Not more than four units are allowed in the following vocationa, subjects, including Business Subjects, Manual Subjects, Domestic Sciencel and Agriculture.

Business Subjects
- Business Law, one-half unit
- Business Arithmetic, one-half unit
- Elementary Bookkeeping, one-half unit
- Advanced Bookkeeping and Business Practice, one unit
- Stenography and Typewriting, two units

Manual Subjects
- Freehand Drawing, two units
- Mechanical Drawing, two units
- Shop Work, two units
- Modeling and Wood Carving, one unit

Domestic Art and Science, two units
Agriculture

One to four units from schools receiving special state aid for Agriculture, and also from other schools in which such course in Agriculture is approved by the State High School Board, as fast as the said schools are prepared to offer work in Agriculture.

DESCRIPTION OF SUBJECTS ACCEPTED FOR ADMISSION

A description of the subjects accepted for admission to the University will be found in the Bulletin of General Information, which will be sent to any address upon application to the Registrar, The University of Minnesota, Minneapolis, Minnesota.

ADVANCED STANDING

The University accepts records from other colleges for credit to advanced standing. Such records are accepted as far as they are equivalent to the work in this University, subject to the approval of the departments concerned. In bringing records from other institutions, the certificates must be on the official blanks of the institution granting the certificate, and should show:

1. The subjects studied and ground covered.
2. The time spent upon each subject.
3. In case of laboratory subjects, a concise statement of work done.
4. The result. It is sufficient to state the subjects were creditably completed.

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee.

DAILY ROUTINE

The daily session is divided into eight recitation periods of fifty minutes each, four in the morning and four in the afternoon. The morning session begins at 8:00 and closes at 12:00 o'clock; the afternoon session extends from 1:00 o'clock until 5:50 o'clock. A general assembly of the Faculty and students is held at 12:00 o'clock on Tuesdays, Thursdays, and Saturdays, at which there are brief and simple religious exercises. The noon hour extends from 12:00 to 1:00 o'clock. Work extends through six days of the week.

EXAMINATIONS

Students failing to receive a semester mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his yearly average in all subjects and present himself for supplementary examinations, according to the program given on page 4.

No other supplementary examination will be given. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to receive a semester mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The Faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

All students who voluntarily register for Military Drill shall be required to drill the entire year and be subject to the same rules and reg-

ulations as other cadets. Such students must receive credit or honorable dismissal from the department before graduating.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination at the end of the first or second semester will be given zero on the examinations.

Students whose absences in either semester exceed four weeks in the aggregate are not permitted to take examinations without special permission of the Faculty.

A fee of five dollars per subject is required for each special examination.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

GRADUATION

Students completing courses of study to the satisfaction of the Faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the Faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations held at the end of the second semester. Irregular attendance will debar a student from entering all final examinations.

THESES

The thesis work is intended to bring in review and connect the work in Mining and Metallurgy, Geology and Mineralogy, Mechanical and Electrical Engineering, Mathematics and Mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the re-opening of Field Work at the School of Mines, Tuesday, September 10, 1912, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to clearly represent the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester senior year will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in first semester senior year.

All preliminary work must be done and final work on project must be under way by December 1st. On April 7th the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30th. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the School.

SPECIAL INFORMATION

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E.M.), Engineer of Mines in Geology [E. M. (Geology)], and Metallurgical Engineer (Met. E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four or five years, and vice versa, provided such candidate completes an additional year's work at the School and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and Mechanic Arts, and in the School of Technical and Applied Chemistry, who contemplate taking a degree in this School after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

SUMMARY OF EXPENSES

FIRST YEAR FIVE-YEAR COURSES

*Incidental fee	$55.00
Books (Estimated)	20.00
Note books and supplies (Estimated)	5.00

FRESHMAN YEAR

*Incidental fee	$55.00
Books (Estimated)	25.00
Draughting instruments (Estimated)	15.00
Note books and supplies (Estimated)	5.00

SOPHOMORE YEAR

*Incidental fee	$55.00
Field work (May 1st to July 1st) Surveying / Geological	100.00 to 150.00
Books (Estimated)	15.00
Note books and supplies (Estimated)	5.00

JUNIOR YEAR

*Incidental fee	$55.00
Field Work (May 1st to July 1st) Metallurgy / Mining	175.00 to 250.00
Books (Estimated)	30.00
Note books and supplies (Estimated)	5.00

*This fee covers all laboratory expenses.

SENIOR YEAR

*Incidental fee	$55.00
Books (Estimated)	30.00
Note books and supplies (Estimated)	5.00

In addition to the first semester incidental fee a deposit fee of $5.00 is required to cover such items as annual rental of post office box, locker key deposit, condition examination fee, and late registration or late payment of fees. The unused balance will be returned at the end of the year.

ORGANIZATION

The organization of the School of Mines dates back to 1889, when the General Faculty of the University recommended to the Board of Regents its establishment. In 1891 the Legislature of the State of Minnesota voted an appropriation for establishing and equipping the School. Two annual appropriations have since been made for its support. The Legislature of 1901 appropriated $47,500 for a new School of Mines Building. In 1903 the Legislature appropriated $25,000 for completing and equipping the School of Mines Building, and in 1905 an additional sum was provided for equipment.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the State, to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the Tax Commission and to do such other work along the lines above outlined as may be requested by other state departments. Co-operation has been effected with the Minnesota Geological Survey and the School of Chemistry.

The Experiment Station is prepared to assist citizens interested in these lines of work; to assay specimens of ore, rocks, clays, and minerals found within the State free of charge.

In submitting samples the sender must state the exact location where each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the Office of the Station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

*This fee covers all laboratory expenses.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, The University of Minnesota, Minneapolis, Minnesota.

THE SCHOOL OF MINES BUILDING

The School of Mines Building is designed to accommodate only the technical work of the School of Mines, as adequate building accommodations and equipment have already been furnished for Chemistry, Geology, Mineralogy, Drawing, and Mechanical and Electrical Engineering. The building is 150 feet long by 65 feet wide. It is a brick building three stories high. The lower floor is occupied by the assaying and metallurgical laboratories; the second floor contains offices, two large lecture rooms, a department library, and a museum; the third floor provides two quiz rooms, a large well-lighted draughting room, a thesis room, a dark room, and a blue print room. This building makes possible the development of the work already begun and offers facilities for more extended work along technical lines.

LOCATION

The University of Minnesota is located in the city of Minneapolis, on the east bank of the Mississippi River. The School of Mines has its buildings and laboratories on the same ground. Students of the School of Mines have, therefore, all the opportunities afforded by a large university.

Minneapolis is surrounded by, and is in direct communication with, several important mining and smelting districts. As the city is a railroad center, all possible transportation facilities are available.

FIELD WORK

Field work is conducted at the iron mines in the northern part of this State, in the copper and iron regions of Michigan, in the mines and smelters of Montana, Colorado, Utah, Arizona, and California, and in the coal mines of Pennsylvania.

At least one of these districts will be visited by each class, affording splendid opportunities for study and observation.

The field work in Mining and Metallurgy consists of two trips, one at the close of the sophomore year and one at the close of the junior year. For details, see pages 26 and 32.

Students must deposit with Cashier, at least two weeks before time set for departure of class, a sum sufficient to cover following expense items:

1st. Board and lodging.
2d. Necessary mine supplies.

Transportation and incidental expenses are not included in the above items and must be met individually.

A statement of expenditures will be rendered at the close of the work and any balance existing will be refunded.

The amount of deposit required will vary according to the locality visited, and will be announced each year when arrangements for the trip are completed.

THE ELLIOT SCHOLARSHIP LOAN FUND

To fulfill the wish of the late Dr. A. F. Elliot to aid young men who find their efforts to obtain a practical education embarrassed through lack of means, the sum of $5,000 was placed in the hands of the Board of Regents as a scholarship fund. The income from this fund is loaned students in the School of Mines on the following conditions: the financial needs of the applicant, his scholarship, moral character, enthusiasm shown in his work, and promise of usefulness in his profession. When money is available, it may be loaned to pay the expenses of worthy students during sickness. The loans are to be repaid, without interest, at the earliest convenience of the recipients.

LIBRARY

The library consists of about two thousand five hundred volumes. This number represents only those works that treat directly of mining and metallurgical subjects.

The School has a complete set of the leading mining and metallurgical journals and other similar books of reference. The leading periodicals are accessible to all. Constant references in lectures compel the student to keep himself well informed as to the latest methods, machinery, and changes in practice going on in his special line of work.

In addition to the above, many thousand volumes on Chemistry, Mineralogy, and Geology complete a most valuable working and reference library. A card index is kept of all articles of value and interest appearing in the leading periodicals.

PHOTOGRAPHY

Photographs of surface and underground appliances, metallurgical plants, copies of drawings and other photographs are indispensable to the study of Mining and Metallurgy. With the report of his field work every student is expected to present photographs, as well as sketches, of

various objects under consideration. There is also a very complete set of lantern slides illustrating the principal methods of underground workings and metallurgical plants, at home and abroad. Several hundred slides have been made in the department's laboratory which bear directly on the work done in Minnesota and the neighboring northwest. Many valuable photographs are constantly being made. Blue prints of these are given students as illustrations. Much time, usually spent in making sketches and diagrams, is thus saved.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thorough courses in Mechanics, Mathematics, Physics, Chemistry, Mineralogy and Geology.

(a) *Assaying*—to determine if ore has value for treatment. (b) *Mining Engineering*—to furnish material for treatment. (c) *Ore Testing*—to determine best methods of treatment. (d) *Ore Dressing*—furnishing products for metallurgical treatment. (e) *Metallurgy*—smelting and refining ores and ore dressing products; reduction to metals.

COURSES IN MINING ENGINEERING

COURSES LEADING TO THE DEGREE OF E. M.

FIRST YEAR—FIVE-YEAR COURSES

First Semester

Chemistry 1, General, six hours.
Mathematics 1, Algebra, four hours
Mathematics 3, Computation and Mensuration, three hours
Mechanical Engineering 3, Foundry Practice, six hours (twelve weeks)
Mechanical Engineering 2, Blacksmithing, six hours (six weeks)
Rhetoric 15, four hours
Spanish 11, Beginning, three hours

Second Semester

Chemistry 1, General, six hours
Mathematics 2, Solid Geometry and Mensuration, three hours
Mathematics 4, Mine Accounting, three hours
Mechanical Engineering 2, Blacksmithing, six hours (twelve weeks)
Mechanical Engineering 1, Carpentry, six hours (six weeks)
Rhetoric 15, four hours
Spanish 11, Beginning, three hours

FRESHMAN YEAR—FOUR AND FIVE-YEAR COURSES

First Semester

Chemistry 2, General and Qualitative Analysis, five hours
Drawing 11, Engineering Drawing, ten hours
Mathematics 5, Algebra and Trigonometry, five hours
Mineralogy 1, General Mineralogy, eight hours

Second Semester

Chemistry 3, Qualitative Analysis, seven hours
Drawing 12, Engineering Drawing, eight hours
Mathematics 6, Trigonometry and Analytic Geometry, five hours
Metallurgy 1, Assaying, twelve hours
Mineralogy 2, Physical Mineralogy, four hours

SOPHOMORE YEAR—FOUR AND FIVE-YEAR COURSES

First Semester

Chemistry 4, Quantitative Analysis, eight hours
Drawing 13, Descriptive Geometry, two hours
Mathematics 7, Analytic Geometry and Calculus, five hours
Metallurgy 2, General and Iron, three hours
Mining 1, Mine Surveying, three hours
Physics 1, General, three hours
Physics 2, Laboratory Practice, two hours

Second Semester

Chemistry 5, Volumetric Analysis, eight hours
Drawing 14, Drafting, four hours

Geology 3, Elements of Geology, three hours
Mathematics 8, Calculus, five hours
Metallurgy 3, Wrought Iron and Steel, three hours
Mining 1, Mine Surveying, three hours
Mining 2, one hour
Physics 3, General, three hours
Physics 4, Laboratory Practice, two hours
Field Work. Months of May, June, July, and August
Mining 3, Surveying, beginning about May 1st
Geology 3a, beginning about June 15th
Underground Mining Work, beginning about July 1st

JUNIOR YEAR—FOUR AND FIVE-YEAR COURSES

First Semester

Experimental Engineering 1, Strength of Materials, four hours
Geology 4, Historical and Economic Geology, three hours
Geology 9, Rock Study, four hours
Mechanics 9, five hours
Mechanics 11, Mine Plant, five hours
Metallurgy 4, Base Metals, four hours
Mining 4, five hours

Second Semester

Experimental Engineering 2, Steam Laboratory, four hours
Geology 10, Petrology, four hours
Mechanics 10, five hours
Metallurgy 5, Precious Metals, four hours
Mining 5, five hours
Mining 6, three hours
Mining 7, Ore Dressing, five hours
Mining 8, Mine Mapping, six hours
Field Work. Months of May, June, July, and August
Metallurgy 10, beginning about May 1st
Mining 9, beginning about May 15th
Underground Mining Work, beginning about June 1st

SENIOR YEAR—FOUR AND FIVE-YEAR COURSES

First Semester

Chemistry 14, Special Problems, eight hours
Electrical Engineering 4, Electric Power, five hours
Geology 12, Ore Deposits, four hours
Mechanics 13, Water Power, five hours
Mechanics 15, Engineering Construction, five hours
Metallurgy 6, Ore Testing, ten hours
Mining 10, Mining Engineering, five hours
Mining 13, Thesis, two hours

Second Semester

Chemistry 18, Iron and Steel Analysis, eight hours
Experimental Engineering 5, Experimental Laboratory, four hours
Geology 13, Special Problems, four hours

Mechanics 16, Mine Plant Design, six hours
Mining 11, Mining Engineering, five hours
Mining 12, Designs and Specifications, eight hours
Mining 13, Thesis, four hours

COURSES LEADING TO THE DEGREE OF E. M. (GEOLOGY)

FIRST YEAR

First Semester

Chemistry, 1, General, six hours
Drawing 11, Engineering Drawing, ten hours
French 1 or 3, three hours
or
German 1 or 4, three hours
Mathematics 1, Algebra, four hours
Rhetoric 15, four hours

Second Semester

Chemistry 1, General, six hours
Drawing 12, Engineering Drawing, eight hours
French 1 or 3, three hours
or
German 1 or 4, three hours
Mathematics 2, Solid Geometry and Mensuration, three hours
Rhetoric 15, four hours

FRESHMAN YEAR

First Semester

Chemistry 2, General and Qualitative Analysis, five hours
French 2 or 5, three hours
or
German 3 or 7, three hours
Mathematics 5, Algebra and Trigonometry, five hours
Mineralogy 1, General Mineralogy, eight hours

Second Semester

Chemistry 3, Qualitative Analysis, seven hours
French 2 or 5, three hours
or
German 3 or 7, three hours
Mathematics 6, Trigonometry and Analytic Geometry, five hours
Metallurgy 1, Assaying, twelve hours
Mineralogy 2, Physical Mineralogy, four hours

SOPHOMORE YEAR

First Semester

Chemistry 4, Quantitative Analysis, eight hours
Drawing 13, Descriptive Geometry, two hours
Mathematics 7, Analytic Geometry and Calculus, five hours
Mineralogy (Advanced), three hours
Mining 1, Mine Surveying, three hours

Physics 1, General, three hours
Physics 2, Laboratory Practice, two hours

Second Semester

Chemistry 5, Volumetric Analysis, eight hours
Drawing 14, Drafting, four hours
Geology 3, Elements of Geology, three hours
Mathematics 8, Calculus, five hours
Metallurgy, three hours
Mining 1, Mine Surveying, three hours
Mining 2, one hour
Physics 3, General, three hours
Physics 4, Laboratory Practice, two hours
Field Work. Months of May, June, July, and August
Mining 3, Surveying, beginning about May 1st
Geology 3a, beginning about June 15th
Special Geological Field Work, beginning about July 1st

JUNIOR YEAR

First Semester

Geology 4, Historical and Economic Geology, three hours
Geology 9, Rock Study, four hours
Mechanics 9, five hours
Mining 4, five hours
Paleontology, three hours
Electives, ten hours

Second Semester

Geology 10, Petrology, four hours
Mechanics 10, five hours
Mining 5, five hours
Mining 6, three hours
Mining 7, Ore Dressing, five hours
Mining 8, Mine Mapping, six hours
Paleontology (Invertebrate), nine hours
Field Work. Months of May, June, July, and August
Mining 9, beginning about May 15th
Underground Mining Work, beginning about June 1st
Practical Geology, beginning about July 1st

SENIOR YEAR

First Semester

Geology 12, Ore Deposits, four hours
Geology of Lake Superior District, five hours
General and Mining Law, three hours
Mechanics 13, Water Power, five hours
Mining 10, Mining Engineering, five hours
Thesis, ten hours

Second Semester

Geology 13, Special Problems, four hours
Geology 13a, Seminar in Ore Deposits, three hours

Geology of Western Mining Districts, five hours
Mining 11, Mining Engineering, five hours
Electives, five hours
Thesis, ten hours

DEPARTMENT OF MINING ENGINEERING

Mining Engineering extends through the sophomore, junior, and senior years. The subjects given, together with the sequence necessary, are treated in the accompanying outline of the course.

In the senior year, problems in hoisting, hauling, pumping, ventilation, and similar subjects become an important part of the work.

DESIGNS AND SPECIFICATIONS

The student makes, in connection with his thesis work, working drawings of mine cars, skips, and other parts of mine equipment that are usually designed and made at the mine.

MINE SURVEYING

The work in Surveying is given in the sophomore year and is designed solely for mining engineers.

The work begins with the elements of plane surveying with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabe or Vermilion Range. The exact location will be announced in March of each year.

The students will be divided into squads of two to four. Each squad must provide itself with a 6-foot steel tape graduated to hundredths. The duration of the course will be seven weeks (5½ days of 8 hours each constitute a week). Each student will be required to complete satisfactorily the following exercises and surveys:

1. Chaining and taping
2. Compass work
3. Adjustment and use of wye and dumpy levels
4. Adjustment of mining transit
5. Reading angles
6. Traverse with transit and steel tape
7. Azimuth traverse with stadia
8. Determination of meridian, latitude, and time by solar and stellar observations
9. Survey of mining claim according to the regulations of the U. S. Government
10. Measurement of earthwork

11. Laying out railroad tangents, curves, and crossings
12. Exercises in plane table work and geological surveying
13. The survey of a mine.

A full equipment of surveying instruments of the latest and best makes is furnished to each squad for this work.

This is followed by a course in Mine Mapping during the second semester of junior year.

Students who furnish satisfactory evidence of proficiency in this work may be given credit therefor. The department, however, reserves the right in any case to require such students to take a theoretical or a practical examination or both.

FIELD WORK IN MINING

Sophomore Year

After the close of the field work in Geology (last two weeks in June) members of the sophomore class are required to engage for six weeks in underground mining work on the Minnesota or Michigan iron ranges, for which they may receive wages.

Junior Year

Upon termination of the junior field work in Metallurgy (about May fifteenth), the members of the junior class, who are candidates for the degree of Engineer of Mines, are required to devote two weeks to the study of mine plant and mine operation under the direction of the department. This work will be given in one of the leading western metal mining districts, exact location to be announced in April of each year. Thereafter, during the months of June, July, and August, the student is required to spend at least eight weeks in actual underground mining work in the west, for which he may receive wages. The department will render all possible assistance in locating students in the camps of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must in person submit this diary to the department on date of reopening of field work. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 10, 1912. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering Field Work in Mine Mapping, Mining, and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned.

The program covering this work is as follows: Metallurgy, September 10th-17th inclusive; Mining, September 18th-30th.

On September 30th all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to

scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before September 30. These reports shall become the property of the School.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reason, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

ORE DRESSING

The lectures and recitations in Ore Dressing extend through the second semester of the junior year, and comprise the detailed study of ore dressing and concentrating machinery, together with the study of typical combinations of dressing machines as found in the several mining districts of the United States.

In connection with the theoretical work, the ore dressing and testing plant of the school is utilized for practical illustrations.

COURSES IN METALLURGY

COURSES LEADING TO THE DEGREE OF MET. E.

FIRST YEAR—FIVE-YEAR COURSES

First Semester

Chemistry 1, General, six hours
Mathematics 1, Algebra, four hours
Mathematics 3, Computation and Mensuration, three hours
Mechanical Engineering 3, Foundry Practice, six hours (twelve weeks)
Mechanical Engineering 2, Blacksmithing, six hours (six weeks)
Rhetoric 15, four hours
Spanish 11, Beginning, three hours

Second Semester

Chemistry 1, General, six hours
Mathematics 2, Solid Geometry and Mensuration, three hours
Mathematics 4, Mine Accounting, three hours
Mechanical Engineering 2, Blacksmithing, six hours (twelve weeks)
Mechanical Engineering 1, Carpentry, six hours (six weeks)
Rhetoric 15, four hours
Spanish 11, Beginning, three hours

FRESHMAN YEAR—FOUR AND FIVE-YEAR COURSES

First Semester

Chemistry 2, General and Qualitative Analysis, five hours
Drawing 11, Engineering Drawing, ten hours
Mathematics 5, Algebra and Trigonometry, five hours
Mineralogy 1, General Mineralogy, eight hours

Second Semester

Chemistry 3, Qualitative Analysis, seven hours
Drawing 12, Engineering Drawing, eight hours
Mathematics 6, Trigonometry and Analytic Geometry, five hours
Metallurgy 1, Assaying, twelve hours
Mineralogy 2, Physical Mineralogy, four hours

SOPHOMORE YEAR—FOUR AND FIVE-YEAR COURSES

First Semester

Chemistry 4, Quantitative Analysis, eight hours
Drawing 13, Descriptive Geometry, two hours
Mathematics 7, Analytic Geometry and Calculus, five hours
Metallurgy 2, General and Iron, three hours
Mining 1, Mine Surveying, three hours
Physics 1, General, three hours
Physics 2, Laboratory Practice, two hours

Second Semester

Chemistry 5, Volumetric Analysis, eight hours
Drawing 14, Drafting, four hours

Geology 3, Elements of Geology, three hours
Mathematics 8, Calculus, five hours
Metallurgy 3, Wrought Iron and Steel, three hours
Mining 1, Mine Surveying, three hours
Mining 2, one hour
Physics 3, General, three hours
Physics 4, Laboratory Practice, two hours
Field Work. Months of May, June, July, and August
Mining 3, Surveying, beginning about May 1st
Geology 3a, beginning about June 15th
Underground Mining Work, beginning about July 1st

JUNIOR YEAR—FOUR AND FIVE-YEAR COURSES

First Semester

Experimental Engineering 1, Strength of Materials, four hours
Geology 4, Historical and Economic Geology, three hours
Geology 9, Rock Study, four hours
Mechanics 9, five hours
Mechanics 11, Mine Plant, five hours
Metallurgy 4, Base Metals, four hours
Mining 4, five hours

Second Semester

Experimental Engineering 2, Steam Laboratory, four hours
Geology 10, Petrology, four hours
Mechanics 10, five hours
Metallurgy 5, Precious Metals, four hours
Mining 5, five hours
Mining 6, three hours
Mining 7, Ore Dressing, five hours
Mining 8, Mine Mapping, six hours
Field Work. Months of May, June, July and August
Metallurgy 10, beginning about May 1st
Mining 9, beginning about May 15th
Smelter Work, beginning about June 1st

SENIOR YEAR—FOUR AND FIVE-YEAR COURSES

First Semester

Chemistry 14, Special Problems, eight hours
Electrical Engineering 4, Electric Power, five hours
Mechanics 13, Water Power, five hours
Mechanics 15, Engineering Construction, five hours
Metallurgy 6, Ore Testing, ten hours
Metallurgy 7, Special Problems, eight hours
Metallurgy 8, Electro-Metallurgy, three hours

Second Semester

Chemistry 16, Electro-Chemical Analysis, six hours
Chemistry 18, Iron and Steel Analysis, eight hours
Experimental Engineering 5, Experimental Laboratory, four hours

Mechanics 18, Mill and Smelter Design, six hours
Metallurgy 9, Metallography, six hours
Metallurgy 11, Thesis, ten hours

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use.

The practical work consists in visits to smelting and refining works which are accessible. The work in Metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags are shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students, who are required to make up the necessary charges and submit their reports in detail. This work is offered to students completing the necessary courses in Mineralogy and Chemistry.

The Assay Laboratories are located in the School of Mines Building and consist of:

1st. Preparation room. This room is 62 feet long by 36 feet wide and accommodates 66 students. Here samples and reagents are weighed preparatory to assaying. Each student is furnished with a complete set of apparatus, including a pulp balance for individual use. All operations are therefore conducted with the greatest economy of time and entirely apart from the furnace room. The separation of the preparation room from the furnace room is of greatest importance. Nearly all ores are crushed and pulverized by suitable machines run by electric motors. Students are compelled to pulverize by hand a minimum number of samples, thereby saving much time for extended and advanced work in special lines.

2d. Furnace room. This room is 60 feet long by 42 feet wide. The high ceiling and special ventilation provided for this room make it a most comfortable assay furnace room. It provides for the accommodation of twelve double-decked muffle furnaces, twenty-four crucible furnaces, and twelve gasoline furnaces. After the sample has been placed in a suitable vessel for fusion, it is taken to the furnace room, which communicates directly with the preparation room.

3d. Balance room. This room is 31 feet long by 16 feet wide. In this room are various types of balances for accurately weighing gold and silver beads and bullion. The room is specially lighted by electric cove lights from the ceiling. The balances are placed on heavy brick piers which are independent of the walls of the building.

ORE TESTING

The lectures treat of the use and purposes of all the machinery connected with the subject, supplemented by detailed drawings.

There are complete testing works connected with the department where the student may see the working of, and handle for himself, crushers, rolls, Huntington mill, concentrating machinery, such as vanners, buddles, jigs, pan for amalgamation, settlers, reverberatory furnaces for oxidizing and oxidizing-chloridizing roasts, leaching and chlorination plants, as well as sizing apparatus and hydraulic separators. Sufficiently large amounts of ore are given to make the necessary tests upon the different machines and the students report the best method of treatment. The first semester of the senior year is devoted to instruction and laboratory work, and is required of students both in Mining and Metallurgy.

The ore testing works meet educational as well as commercial needs.

Educational.—The ore testing plant acquaints the student with the construction and manipulation of the principal typical machines used in the leading ore dressing establishments of the country. It is here that students in Mining and Metallurgical Engineering get the requisite practical experience. They handle all machines and operate on sufficiently large amounts of material to determine the methods best suited to a given ore to extract the largest amount of metal with the least possible loss.

Commercial.—Ore testing works are an important factor in mining and metallurgical projects. The commercial object is to determine the best method of treating a given ore so as to yield the largest percentage of the metal it contains at the least possible cost. Samples varying from 500 pounds to car load lots can be treated by various methods.

The ore testing works are located on the east bank of the Mississippi between the Great Northern and Northern Pacific railroads. Located at this point on the University campus, it offers the very best facilities for both educational and commercial purposes.

As the funds appropriated for the erection of such a plant were sufficient to purchase only the necessary machinery, the business men of

Minneapolis generously provided a suitable building. This building, 94 by 66 feet, is built of brick and stone.

Machinery.—The plant contains all the machinery necessary to illustrate the various processes of ore testing, viz.: A Bridgman mechanical sampler, size B; a link belt bucket elevator; a pulley feeder complete; a pair of 12½ by 12 geared rolls complete; a four compartment spitzkasten; a three compartment Hartz jig; a Collum jig complete with cone for driving; a three and a half foot Huntington mill complete; a three stamp mill, 275-pound stamps; a five stamp mill, 850-pound stamps; a Challenge automatic feeder for five-stamp battery; a suspended Challenge feeder for three-stamp battery; a Tulloch feeder for Huntington mill; a single deck buddle, twelve feet in diameter; a four-foot plain belt Frue vanner; a Cammett concentrator; a Hooper pneumatic concentrator; a Century drop motion jig; a three-foot amalgamating pan; a five-foot settler; a Bruckner roasting furnace, with fire box on wheels; a chlorination barrel; a battery tightener; a two-horsepower vertical boiler; a steam drying pan; three trommels, with driving arrangement and gears; a one thousand pound Reedy elevator, complete with worm gear; two overhead crawls, each with eighty-foot track; one-ton pulley block; a quarter-ton pulley block; a scoop car, with flat wheels; two twenty-horse power electric motors; three MacDermott automatic samplers, etc.

FIELD WORK IN METALLURGY

At the end of junior year opportunity is given the student to study metallurgical operations at one or more smelting works. This work will begin about May 1st. Not over two weeks' time will be devoted to this work.

Upon termination of the junior field work in Metallurgy and two weeks in Mining (not later than June 1st), the members of the junior class who are candidates for the degree of Metallurgical Engineer, are required to spend at least eight weeks in practical work in one or more of the smelters of the West, for which he may receive wages. The department will render all possible assistance in locating students in the camps of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must, in person, submit this diary to the department on date of reopening of field work. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 10, 1912. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering field work in Metallurgy and Mining must be prepared at the School of Mines under the direct supervision of the departments concerned.

The program covering this work is as follows: Metallurgy, September 10th-21st, inclusive; Mining, September 23d-30th.

On September 30th all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before September 30th. These reports shall become the property of the School.

DEPARTMENTAL STATEMENTS

CHEMISTRY

George B. Frankforter, Ph.D., Professor	114 Chemistry Building
Charles F. Sidener, B.S., Professor	203 Chemistry Building
Francis C. Frary, Ph.D., Assistant Professor	108 Chemistry Building
Paul H. M-P. Brinton, Instructor	205 Chemistry Building
Lillian Cohen, M.S., Instructor	106 Chemistry Building

1. General Chemistry — Miss Cohen

*Six credits (six hours per week); both semesters. Required of first-year students, five-year courses.

Recitation and laboratory work. The course includes a study of the common elements and their compounds, with an introduction to the modern theories of chemistry.

2. General and Qualitative Analysis — Messrs. Frankforter and Brinton

Four credits (three lectures, two laboratory hours per week); first semester. Required of freshmen.

The course includes special general chemistry and the reactions of the metals as applied to their separation and identification.

3. Qualitative Analysis — Messrs. Frankforter and Brinton

Four credits (one lecture, six laboratory hours per week); second semester. Open to students completing Course 2. Required of freshmen.

The work in this course will include examination of alloys, minerals, slags, and other compounds.

4. Quantitative Analysis — Mr. Sidener and Assistants

Five credits (two lectures, six laboratory hours per week); first semester. Open to students completing Course 3. Required of sophomores.

The course includes an introduction to quantitative and a beginning of gravimetric analysis.

5. Volumetric Analysis — Mr. Sidener and Assistants

Five credits (two lectures, six laboratory hours per week); second semester. Open to students completing Course 4. Required of sophomores.

The course includes an introduction to volumetric determinations with a discussion of standard solutions and the necessary stoechiometric calculations.

14. Special Problems — Mr. Sidener and Assistants

Five credits (two lectures, six laboratory hours per week); first semester. Open to students completing Course 5. Required of seniors in E. M. and Met. E. Courses.

The course includes the working out of various mineralogical, technological, and metallurgical problems, with work on ores of base metals, limestones, slags, etc.

*A credit is one recitation or lecture hour per week, per semester. Two laboratory hours are equal to one credit.

16. Electro-Chemical Analysis — Mr. Frary

Four credits (two lectures, four laboratory hours per week); second semester. Open to students completing Course 14. Required of seniors in Met. E. Courses.

The course includes the qualitative and quantitative separation of metals by electrolysis.

18. Iron and Steel Analysis — Mr. Sidener and Assistants

Five credits (two lectures, six laboratory hours per week); second semester. Open to students completing Course 14. Required of seniors in E. M. and Met. E. Courses.

The course includes the rapid determination of iron by the various methods, as well as the determination of associated elements, sulphur, phosphorus, silicon, manganese, carbon, and others.

DRAWING AND DESCRIPTIVE GEOMETRY

William H. Kirchner, B.S., Professor
209 Main Engineering Building

Frank B. Rowley, B.S., M.E., Instructor
209 Main Engineering Building

Robert W. French, B.S., Instructor
209 Main Engineering Building

————————————, Instructor

11. Engineering Drawing — Messrs. Kirchner and French

Five credits (ten drafting hours per week); first semester. Required of freshmen in E. M. and Met. E. Courses, and of first-year students in E. M. (Geol.) Course.

Sketching, lettering, representation, parallel and radial projection, elements of engineering drawing, representation of details of machines and structures, interpretation of working drawings.

12. Engineering Drawing — Mr. French

Four credits (eight drafting hours per week); second semester. Open to students completing Course 11. Required of freshmen in E. M. and Met. E. Courses, and of first-year students in E. M. (Geol.) Course.

Continuation of Course 11 as outlined above. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Maps and sketches. Brush and pen conventions.

13. Descriptive Geometry — Mr. Kirchner

Two credits (two lectures per week); first semester. Open to students completing Course 12 and Mathematics 6. Required of sophomores.

Projection—central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems.

14. Drafting — Messrs. Rowley and French

Two credits (four drafting hours per week); second semester. Open to students completing Course 13. Required of sophomores.

Graphics, machine drafting, and structural drafting. Instruction in drafting room methods.

ELECTRICAL ENGINEERING

George D. Shepardson, M.A., M.E., Professor
30 Electrical Engineering Building

William T. Ryan, E.E., Assistant Professor
14 Electrical Engineering Building

4. Electric Power — Mr. Ryan

Three credits (one lecture, four laboratory hours per week); first semester. Open to students completing Physics 3 and 4. Required of seniors in E. M. and Met. E. Courses.

Elements of theory and practice of electrical measurements, wiring, dynamos, motors, and electric lighting.

EXPERIMENTAL ENGINEERING

William H. Kavanaugh, M.E., Professor, 107 Experimental Engineering Building

Charles F. Shoop, B.S., Assistant Professor, 107 Experimental Engineering Building

1. Strength of Materials — Mr. Shoop

Two credits (four laboratory hours per week); first semester. Open to students taking Mechanics 9. Required of juniors in E. M. and Met. E. Courses.

Laboratory work, investigating the strength and physical qualities of iron, steel, brass, copper, belting, chains, beams, brick, and stone.

2. Steam Laboratory — Mr. Shoop

Two credits (four laboratory hours per week); second semester. Open to students completing Course 1. Required of juniors in E. M. and Met. E. Courses.

Exercises in valve setting, indicator practice, calibration of steam gauges, efficiency of screws and hoists.

5. Experimental Laboratory — Mr. Kavanaugh

Two credits (four laboratory hours per week); second semester. Open to students completing Course 2. Required of seniors in E. M. and Met. E. Courses.

Hydraulic measurements. Calibration of weirs, nozzles, meters, and other hydraulic apparatus, calorimetry; tests of pumps, engines, and boilers.

FRENCH AND SPANISH

CHARLES W. BENTON, M.A., Litt.D., Professor of Romance Languages 200 Folwell Hall
CHARLES M. ANDRIST, M.L., Professor 228 Folwell Hall
JULES T. FRELIN, B.A., Assistant Professor 228 Folwell Hall

FRENCH

1. Beginning — Messrs. ANDRIST and FRELIN

Six credits (three hours per week); both semesters. Open to first-year students in E. M. (Geol.) Course.

French Grammar and Reader; modern texts.

2. Intermediate — Mr. ANDRIST

Six credits (three hours per week); both semesters. Open to students completing Course 1.

Modern texts will be read, including some of the works of Coppee, Merimee, Daudet, Scribe, etc.

3. Advanced Grammar and Composition — Mr. ANDRIST

Six credits (three hours per week); both semesters. Open to students in E. M. (Geol.) Course who enter with two years of French.

Readings from modern authors, including selections from Coppee, Feuillet, and Sandeau.

5. The Classical Period of French Literature — Mr. BENTON

Six credits (three hours per week); both semesters. Open to students completing Course 2 or 3.

The reading of works and selections produced during the classical period of French literature, and conversations in French concerning the same. The works of Corneille, Racine, Moliere, La Fontaine, etc. Compositions.

SPANISH

11. Beginning — Mr. FRELIN

Six credits (three hours per week); both semesters. Required of first-year students in E. M. and Met. E. Courses.

Monsanto and Languellier, *Spanish Course-Josselyn;* Worman, *First Spanish Book;* Bransby, *Spanish Reader.*

GERMAN

JOHN G. MOORE, B.A., Professor of German 210 Folwell Hall
HANS JUERGENSEN, M.A., Assistant Professor 215 Folwell Hall
OSCAR C. BURKHARD, M.A., Assistant Professor 214 Folwell Hall
RICHARD WISCHKAEMPER, M.A., Instructor 216 Folwell Hall

1. Beginning — Messrs. JUERGENSEN, BURKHARD, and WISCHKAEMPER

Six credits (three hours per week); both semesters. Open to first-year students in E. M. (Geol.) Course.

Pronunciation, grammar, conversation and composition; selected reading in easy prose and verse.

3. Scientific Intermediate Messrs. JUERGENSEN, BURKHARD, and WISCHKAEMPER

Six credits (three hours per week); both semesters. Open to students completing Course 1.

This course is arranged to meet the peculiar needs of students of the School of Mines. Text: Merckel's *Bilder aus der Ingenieurtechnik.*

4. Prose and Poetry Messrs. MOORE, JUERGENSEN, BURKHARD, and WISCHKAEMPER

Six credits (three hours per week); both semesters. Open to first-year students in E. M. (Geol.) Course who enter with two years of German.

Stern's *Aus deutschen Meisterwerken*; Goethe's *Gedichte;* Heine's *Buch der Lieder.* Geography, history, and legend. Review of German grammar throughout the year. This course may be supplemented.

7. Advanced Scientific Reading Messrs. JUERGENSEN and BURKHARD

Six credits (three hours per week); both semesters. Open to students who have taken Course 3 or 4.

Reading of scientific monographs and periodicals.

MECHANICAL ENGINEERING

JOHN J. FLATHER, Ph.B., M.E., Professor
12 Mechanical Engineering Building
S. CARL SHIPLEY, B.S., M.E., Assistant Professor
18 Mechanical Engineering Building
WILLIAM H. RICHARDS, Instructor
28 Mechanical Engineering Building
EDWARD QUIGLEY, Instructor Mechanical Engineering Building
PETER PETERSON, Instructor Mechanical Engineering Building

1. Carpentry Mr. RICHARDS

Four credits (six hours per week, six weeks); second semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Wood working, use of tools; lathe and bench work. Patterns for moulding, core boxes, flasks. Lectures and practice.

2. Blacksmithing Messrs. SHIPLEY and QUIGLEY

Two credits (six hours per week, eighteen weeks); first semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Use of tools, forging, welding, tool dressing, tempering. Lectures and practice.

3. Foundry Practice Mr. PETERSON

Three credits (six hours per week, twelve weeks); first semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Moulding, casting, mixing metals, brass work, and core making. Shop practice, recitations, and lectures.

MECHANICS AND MATHEMATICS

ELTING H. COMSTOCK, M.S., Professor 22 School of Mines Building
EDWIN M. LAMBERT, M.E., Assistant Professor
22 School of Mines Building
JULIUS H. SANTO, E.M., Instructor 22 School of Mines Building

1. Algebra Mr. SANTO

Four credits (four recitations per week); first semester. Required of first-year students, five-year courses.

Review of Elementary Algebra, equations with one, two, or more unknown quantities, inequalities, involution and evolution, theory of exponents, surds, quadratic equations, both numerical and literal, equations with one or more unknown quantities that can be solved by means of quadratic equations, progressions.

2. Solid Geometry and Mensuration Mr. SANTO

Three credits (three recitations per week); second semester. Required of first-year students, five-year courses.

Demonstrations of most important theorems, volumes, approximate volumes, prismoidal formula, etc.

3. Computation and Mensuration Mr. COMSTOCK

Three credits (three recitations per week); first semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Approximate computation, graphs and graphical computation, logarithms and logarithmic computation, areas and approximations of areas.

4. Elementary Mine Accounting Mr. LAMBERT

Three credits (three lectures per week); second semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Elementary accounting in general, applications to mine accounts; primary records, labor, supply, mine and mill products, and fund sheets; secondary records, invoice, labor and supply, mine and mill cost sheets, trial balance, etc.

5. Algebra and Trigonometry Mr. SANTO

Five credits (five recitations per week); first semester. Required of freshmen.

Functions and functional notation, factors and roots of general quadratics, factor and remainder theorems, factors and values of functions, determinants, development of functions and undetermined coefficients, derived functions, theory of equations, permutations and combinations; trigonometric ratios, right triangles, general definitions of trigonometric functions, analytic relations, addition formulas, etc.

6. Trigonometry and Analytic Geometry Mr. SANTO

Five credits (five recitations per week); second semester. Open to students completing Course 5. Required of freshmen.

Trigonometric equations, oblique triangles, spherical formulas and solution of spherical triangles; systems of co-ordinates, loci, straight line, transformations, equations of conics, properties of conics.

7. Analytic Geometry and Calculus Mr. LAMBERT

Five credits (five recitations per week); first semester. Open to students completing Course 6. Required of sophomores.

General equation of second degree, higher plane curves, co-ordinates in space, point, plane, straight line, quadric surfaces; nature of differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, elementary integration, expansion of functions, indeterminate forms, partial derivatives, change of variable.

8. Calculus — Mr. LAMBERT

Five credits (five recitations per week); second semester. Open to students completing Course 7. Required of sophomores.

Applications continued, rational fractions, rationalization, formulas of reduction, multiple integration, various systems of co-ordinates, approximate integration, hyperbolic functions, some differential equations of mechanics; adjustments of observations.

9. Mechanics — Mr. LAMBERT

Five credits (five recitations per week); first semester. Open to students completing Course 8, and Physics 3. Required of juniors.

Statics and dynamics, rectilinear, circular, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy; elementary mechanics of materials.

10. Mechanics — Mr. LAMBERT

Five credits (five recitations per week); second semester. Open to students completing Course 9. Required of juniors.

Mechanical and elastic properties of materials of construction; beams, shafts, columns, reinforced concrete, hollow cylinders and spheres, rollers, plates; theory of internal stress.

11. Mine Plant — Mr. COMSTOCK

Five credits (five lectures per week); first semester. Open to students taking Course 9. Required of juniors in E. M. and Met. E. Courses.

Discussion of the machinery and appurtenances employed in the equipment of mines. Hoisting, pumping, air compression, headframes, ore bins, etc.

13. Hydraulics and Water Power — Mr. COMSTOCK

Five credits (five recitations and lectures per week); first semester. Open to students completing Course 10. Required of seniors.

Laws of the equilibrium, pressure and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, number and type of units to install, speed control, power house equipment, transmission.

15. Engineering Construction — Messrs. COMSTOCK and LAMBERT

Three credits (one lecture, four drafting hours per week); first semester. Open to students completing Course 10. Required of seniors in E. M. and Met. E. Courses.

Analytic and graphic resolution of stresses in framed structures, loads, stresses in mining structures, design of mining structures.

16. Mine Plant Design — Mr. COMSTOCK

Three credits (six drafting hours per week); second semester. Open to students completing Course 15. Required of seniors in E. M. Course.

A study of power possibilities, costs, etc., and design of a power plant, surface equipment, and structures in connection with thesis work.

18. Mill and Smelter Design — Mr. COMSTOCK

Three credits (six drafting hours per week); second semester. Open to students completing Course 15. Required of seniors in Met. E. Courses.

A study of the construction and mechanical equipment of mills and smelters in connection with thesis work.

METALLURGY

WILLIAM R. APPLEBY, M.A., Professor — 27 School of Mines Building
PETER CHRISTIANSON, B.S., E.M., Professor — 25 School of Mines Building
LEVI B. PEASE, M.S., Professor — 26 School of Mines Building
EDMUND NEWTON, E.M., Instructor — 25 School of Mines Building

1. Assaying — Mr. APPLEBY and ASSISTANTS

Eight credits (four lectures and eight laboratory hours per week); second semester. Open to students completing Mineralogy 1. Required of freshmen in E. M. and Met. E. Courses.

Determination of values of ores, metallurgical products and bullion.

2. General Metallurgy and Metallurgy of Iron — Mr. CHRISTIANSON

Three credits (three lectures per week); first semester. Open to students completing Course 1. Required of sophomores in E. M. and Met. E. Courses.

Including the subjects of combustion, fuels, refractory materials, and furnaces. Lectures and recitations on metallurgy of iron.

3. Metallurgy of Wrought Iron and Steel — Mr. CHRISTIANSON

Three credits (three lectures per week); second semester. Open to students completing Course 2. Required of sophomores in E. M. and Met. E. Courses.

Consideration of the principles of manufacture, details of plant construction, and chemical and physical phenomena.

4. Metallurgy of the Base Metals — Mr. PEASE

Four credits (four lectures per week); first semester. Open to students completing Course 3. Required of juniors in E. M. and Met. E. Courses.

Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining methods.

5. Metallurgy of the Precious Metals — Mr. PEASE

Four credits (four lectures per week); second semester. Open to students completing Course 4. Required of juniors in E. M. and Met. E. Courses.

Gold, silver, and platinum. Methods and principles of cyanidation, chlorination, amalgamation, and lixiviation asapplied to the treatment of the above.

6. Ore Testing — Mr. APPLEBY and ASSISTANTS

Six credits (two lectures and eight laboratory hours per week); first semester. Open to students completing Course 5 and Mining 7. Required of seniors in E. M. and Met. E. Courses.

Determination of methods of ore treatment. stamping, concentration, cyanidation, roasting, chlorination, lixiviation, and amalngamatio.

7. Special Problems in Metallurgy — Mr. Appleby and Assistants

Four credits (eight laboratory hours per week); first semester. Open to students taking Course 6. Required of seniors in Met. E. Course.

Research work preparatory to thesis.

8. Electro-Metallurgy — Mr. Christianson

Three credits (three lectures per week); first semester. Open to students completing Course 5. Required of seniors in Met. E. Courses.

A study of the reduction of ores, refining of metals and production of metals by electrolytic deposition; and the use of the electric furnace for smelting of ores, refining metals, and the manufacture of refractory alloys.

9. Metallography — Mr. Newton

Four credits (two lectures, four laboratory hours per week); second semester. Open to students completing Course 3. Required of seniors in Met. E. Courses.

A study of the microstructure of metals and alloys as affected by heat and industrial treatments, together with the influence of changes of structure on their properties. Special attention is given to siderurgic products.

10. Field Work in Metallurgy — Mr. Appleby and Assistants

Two credits (eight hours per day in field for seven days); June following second semester. Open to students completing Course 5. Required of juniors.

Study of metallurgical operations at smelters and mills. Detailed report is required covering plants visited.

11. Thesis and Specifications — Messrs. Appleby and Comstock

Five credits (ten hours, conference and laboratory); second semester. Open to students completing Course 9. Required of seniors in Met. E. Courses.

Detailed investigations of ore treatment, with report including designs and specifications for suitable plants.

MINING ENGINEERING

Charles E. van Barneveld, B.A., Sc., E.M., Professor
28 School of Mines Building

Edward P. McCarty, E.M., Professor 28 School of Mines Building

Merton S. Kingston, E.M., Assistant Professor
28 School of Mines Building

Ervin W. McCullough, E.M., Instructor
28 School of Mines Building

1. Mine Surveying — Messrs. McCarty and Kingston

Six credits (three lectures per week); both semesters. Open to students completing Mathematics 6. Required of sophomores.

Computation, platting, and problems with special reference to mine surveying.

2. Mining — Mr. van Barneveld

One credit (one lecture per week); second semester. Required of sophomores.

Explosives and blasting.

3. Field Work — Mr. van Barneveld and Assistants

Eight credits (eight hours a day for seven weeks); second semester. Open to students completing Mining 1. Required of sophomores.

Practice in general surveying during month of May. Practice in underground surveying during first two weeks of June. This work is given on the Iron Ranges.

4. Mining — Mr. van Barneveld

Five credits (five lectures per week); first semester. Open to students completing Course 2. Required of juniors.

Mode of occurrence of ore bodies; prospecting, drilling and blasting. Use of churn and diamond drill.

5. Mining — Mr. van Barneveld

Five credits (five lectures per week); second semester. Open to students completing Course 4. Required of juniors.

Shaft-sinking, tunneling, drifting, stoping, timbering.

6. Mining — Mr. van Barneveld

Three credits (three lectures per week); second semester. Open to students completing Course 4. Required of juniors.

Methods of metal mining. Methods of coal mining. Hydraulic mining. Quarrying.

7. Ore Dressing — Mr. McCarty

Five credits (five lectures per week); second semester. Open to students completing sophomore work. Required of juniors.

Mechanical preparation of ore for the markets, for metallurgical treatment, etc.

8. Mine Mapping — Mr. Kingston

Three credits (six drafting hours per week); second semester. Open to students completing Course 3. Required of juniors.

Mine mapping in accordance with prevalent practice in the western mining districts. Ore and stripping estimates and mine maps based on Mesabe Range practice.

9. Practical Mining — Mr. van Barneveld and Assistants

Eight credits (eight hours per day for ten weeks); summer vacation. Open to students completing Course 6. Required of juniors.

Study of mining operations. Mine plant and equipment and practical mining work a mine to be selected by department during months of May, June, July, and August.

10. Mining and Mining Engineering — Mr. van Barneveld

Five credits (five lectures per week); first semester. Open to students completing Mining 9. Required of seniors in E. M. Courses.

Mining machinery, underground transportation, hoisting, pumping, and ventilation. Electricity applied to mining.

11. Mining and Mining Engineering — Mr. VAN BARNEVELD

Five credits (five lectures per week); second semester. Open to students completing Mining 10. Required of seniors in E. M. Courses.

Mine management, mine accounts, mining law, mining accidents, examination of a mining property, sampling ore reserves.

12. Designs and Specifications — Messrs. VAN BARNEVELD and COMSTOCK

Four credits (eight drafting hours per week); second semester. Open only to seniors in regular standing. Required of seniors in E. M. Courses.

Designs of mine cars, skips, head-frames, etc., in connection with thesis work.

13. Thesis — Messrs. VAN BARNEVELD, MCCARTY, and MCCULLOUGH

Two and four credits (two and four-hour conferences); both semesters. Open only to seniors in regular standing. Required of seniors in E. M. Courses.

Conference with individual students. This work is based upon a review of the preceding technical work and field work.

MINERALOGY AND GEOLOGY

WILLIAM H. EMMONS, Ph.D., Professor	108 Pillsbury Hall
FRANK F. GROUT, M.S., Assistant Professor	102 Pillsbury Hall
FREDERICK W. SARDESON, Ph.D., Assistant Professor	103 Pillsbury Hall
OLIVER BOWLES, M.A., Instructor	102 Pillsbury Hall
EDGAR K. SOPER, B.A., Instructor	112 Pillsbury Hall

1. General Mineralogy — Messrs. GROUT and BOWLES

Six credits (four lectures, four laboratory hours per week); first semester. Required of freshmen.

The development of the systems of crystallization; the morphological, physical, and chemical characters of minerals; classification and description of common minerals; laboratory work, involving the application of chemical and blowpipe tests to the identification of species, with demonstrations; determination of minerals by physical properties, and sight identification The occurrence, genesis, and use of minerals.

2. Physical Mineralogy — Messrs. GROUT and BOWLES

Three credits (two lectures, two laboratory hours per week); second semester. Open to students completing Course 1. Required of freshmen.

A continuation of Course 1, special attention being given to economic and rock-forming minerals. Laboratory work, mineral determination and sight identification; introduction to the use of the goniometer and microscope. Reference reading and field excursions.

3. Elements of Geology — Mr. SOPER

Three credits (three lectures per week); second semester. Required of sophomores.

The course is a synoptical treatment of the materials of the earth and of geologic processes; physiographic, structural, and dynamic geology, with a brief introduction to historical geology. Geologic structure is emphasized and the lectures are reinforced by the study of geologic maps.

3a. Field Work — Mr. Soper

One credit (first two weeks in June). Required of sophomores.

A two-week excursion to the Iron Ranges for practice in field methods, such as tracing contacts, working out structures, and constructing and interpreting geologic maps.

4. Historical and Economic Geology — Messrs. Emmons and Soper

Three credits (three lectures a week); first semester. Required of juniors.

(a) Historical Geology. The geologic history of North America, with special reference to its syngenetic mineral deposits.

(b) Economic Geology. A study of the occurrence, genesis, distribution, and uses of the non-metallic minerals of economic value, including a discussion of the geologic guides to prospecting for these deposits.

9. Elements of Rock Study — Messrs. Grout and Bowles

Two credits (four laboratory hours per week); first semester. Open to students completing Course 3. Required of juniors.

The composition of the earth's crust, a general treatment of the origin, occurrence, and genesis of igneous, sedimentary and metamorphic rocks; their mineral and chemical composition; their structure, texture and physical constitution; the alteration of rocks; the classification of igneous rocks; an introduction to the use of the microscope.

10. Petrology — Messrs. Grout and Bowles

Two credits (four laboratory hours per week); second semester. Open to students completing Course 9. Required of juniors.

Laboratory work, lectures, and reference reading. The identification of minerals and rocks by optical study; a study of igneous rocks, followed by that of crystalline schists and metamorphic rocks; the origin and classification of rocks.

12. Ore Deposits — Messrs. Emmons and Soper

Four credits (four lectures per week); first semester. Open to students completing Course 10. Required of seniors.

A discussion of ore deposition; the nature, distribution, and genesis of metalliferous ore deposits of the United States. A study of the relation of ore deposits to geologic structure and of the changes which ore deposits undergo through oxidation and related processes. The course includes laboratory work illustrating the use of mine maps and geologic cross sections through mines, and detailed laboratory studies of reports on mining districts.

13. Special Problems in Ore Deposits — Messrs. Emmons and Soper

Two credits (four laboratory hours per week); second semester. Open to students completing Course 12. Required of seniors in E. M. and E. M. (Geol.) Courses.

Lectures on field and laboratory methods. A study of metallogenic epochs and metallographic provinces, particularly those of the United States.

13a. Seminar in Ore Deposits — Mr. Emmons

Three credits (three hours per week); second semester. Open to students completing Course 12. Required of seniors in E. M. (Geol.) Course.

Selected problems. Development of methods of research.

PHYSICS

JOHN ZELENY, Ph.D., Professor — 15 Physics Building
JAMES COXE SANDERSON, Ph.D., Instructor — 32 Physics Building

1. General Physics — Messrs. JOHN ZELENY and SANDERSON

Three credits (three hours per week); first semester. Open to students completing Mathematics 6. Required of sophomores.

Mechanics of solids and fluids, heat and sound. This is the first part of an elementary course in Physics, designed for those who do not intend to pursue the subject longer than one year. The course is experimental rather than mathematical and gives the student a general knowledge of the fundamental principles of the subject. There will be one experimental lecture and two recitations each week.

2. General Laboratory Practice — Mr. SANDERSON

One credit (two hours per week); first semester. Open to students taking Course 1. Required of sophomores.

Physical measurements in the mechanics of solids and fluids, and in heat and sound, giving the student a knowledge of experimental methods.

3. General Physics — Messrs. JOHN ZELENY and SANDERSON

Three credits (three hours per week); second semester. Open to students completing Course 1. Required of sophomores.

Light, electricity and magnetism. This is the second part of the elementary course begun under Course 1. The treatment is experimental and the fundamental principles of the subjects, including those of radioactivity, ionization, X radiation, and the electrical constitution of matter, are discussed and illustrated. There will be one experimental lecture and two recitations each week.

4. General Laboratory Practice — Mr. SANDERSON

One credit (two hours per week); second semester. Open to students taking Course 3. Required of sophomores.

Physical measurements in light, electricity, and magnetism, giving the student a knowledge of experimental methods.

RHETORIC

JOSEPH M. THOMAS, Ph.D., Professor — 310 Folwell Hall
WARREN T. POWELL, M.A., Instructor — 410 Folwell Hall

15. Rhetoric and Composition — Mr. POWELL

Eight credits (four hours per week); both semesters. Required of all freshmen.

This course is planned with special reference to the needs of engineering students. Practical training in writing will be given, and in connection with the written work the student will be required to study the work of those writers who have handled scientific subjects with clearness and power.

To broaden the scope of the student's knowledge and interests a course of outside reading will also be required.

STUDENTS

SENIORS—24

Bjorge, Guy N., Duluth
Coventry, Edward D., Duluth
Dickson, Robert H., Minneapolis
Hagstrom, Leonard J., Minneapolis
Harrington, Geo. L., Minneapolis
Hewitt, Ezra A., Minneapolis
Kennedy, Charles T., Minneapolis
Knox, Lafayette F., St. Paul
Kremer, Edward G., Grand Rapids
Lea, John, Zumbrota
Lewis, John W., Minneapolis
McAdams, Howard R., Minneapolis
Martin, Lynn U., Grand Meadow
O'Brien, J. Chas., St. Paul
Olson, Walter S., St. Paul
Perry, Joe B., Minneapolis
Prouty, Roswell W., St. Paul
Quinn, Max F., Minneapolis
Stevens, Howard E., Stillwater
Taylor, W. L., Dundas
Victor, Albin F., Lindstrom
Wallinder, Arthur, Duluth
Walter, Rollie B., Delano
Woodis, Clark N., Amboy

JUNIORS—17

Coady, Leo J., Minneapolis
Cohen, Julius M., St. Paul
Ely, Robert H., Duluth
Hammond, Arthur H., Minneapolis
Hanson, J. Bernard, Minneapolis
Harvey, Harry J., Duluth
Hondrum, Olaf, Bemidji
Ladd, Greeley, Minneapolis
Larson, John Ed., Minneapolis
McCormack, Clyde P., Minneapolis
Michie, Roy G., Montevideo
Nissen, Arvid E., Minneapolis
Ofsthun, Norman H., Glenwood
Quinlan, Howard, St. Paul
Walker, Charles A., Brainerd
Wasson, Harold J., Minneapolis
Williams, James H., Virginia

SOPHOMORES—14

Amidon, Richard G., Minneapolis
Bierman, Alfred, Litchfield
Eidemiller, Howard N., St. Paul
Haugan, Albert C., Hanska
Johnson, Roy R., St. Louis Park
Larson, Ernest L., Akeley
Nordale, Carl E., Minneapolis
Potter, Orrin W., St. Paul
Ravicz, Louis, Minneapolis
Richard, Charles L., Stillwater
Schultze, Max F., Walker
Van Cleve, R. H., Minneapolis
Vorck, Charles R., St. Paul
Williams, Paul S., Lake Benton

FRESHMEN—22

Buresh, Charles E., Lakefield
Butler, William V., Little Falls
Chatfield, William E., Minneapolis
Christenson, Alfred, Madelia
Clark, Malcolm W., Northfield
Coller, Walter A., St. Paul
Collins, Leon T., Pine Island
Dopp, Lawrence, Ashland, Wis.
Glass, Archie, Duluth
Harmon, Sidney E., St. Paul
Heilig, Louis S., Minneapolis
Johnson, Fred C., Willmar
Kerr, Charles D., Minneapolis
Lee, Martinus, Minneapolis
Lee, Oscar, St. Paul
Montgomery, Daniel, Worthington
Neerland, Herman, Minneapolis
Nord, Harry H., St. Paul
Sanchez, Richard M., Tarma, Peru
Stene, James, Minneapolis
Urquhart, George K., St. Paul
Wade, Henry H., Hopkins

FIRST YEAR CLASS—21

Aronson, Sam, St. Paul
Barskey, Philip M., Minneapolis
Capser, Leo W., St. Paul
Carroll, Lawrence, Sparta, Wis.
Dovre, Adolph, Sleepy Eye
Ellis, George J., Minneapolis
Evleth, Everett B., St. Paul
Josephson, Samuel, Minneapolis
Krogh, Alvin T., Minneapolis
Levy, Martinio, Sao Paulo, Brazil
McDermid, Archie J., Duluth
McHardy, Roy H., Minneapolis
Marr, Ralph C., Minneapolis
Marr, William N., Minneapolis
Murphy, Vernon R., Centuria, Wis.
Neumeier, Frederick G., Stillwater
Oglesby, Fred B., Valley City, N. D.
Ostrom, George E., Stillwater
Sweetman, Edwin, Aitkin
Tollefson, Russell, Minneapolis
Williams, Maurice W., Minneapolis

The University of Minnesota

THE SCHOOL OF MINES

1913-1914

BULLETIN OF THE UNIVERSITY OF MINNESOTA
VOL. XVI, NO. 14. JUNE 1913

Entered at the Post Office
in Minneapolis as second-class matter
MINNEAPOLIS, MINN.

The Bulletin of the University of Minnesota is issued by the University of Minnesota as often as twice a month during the university year.

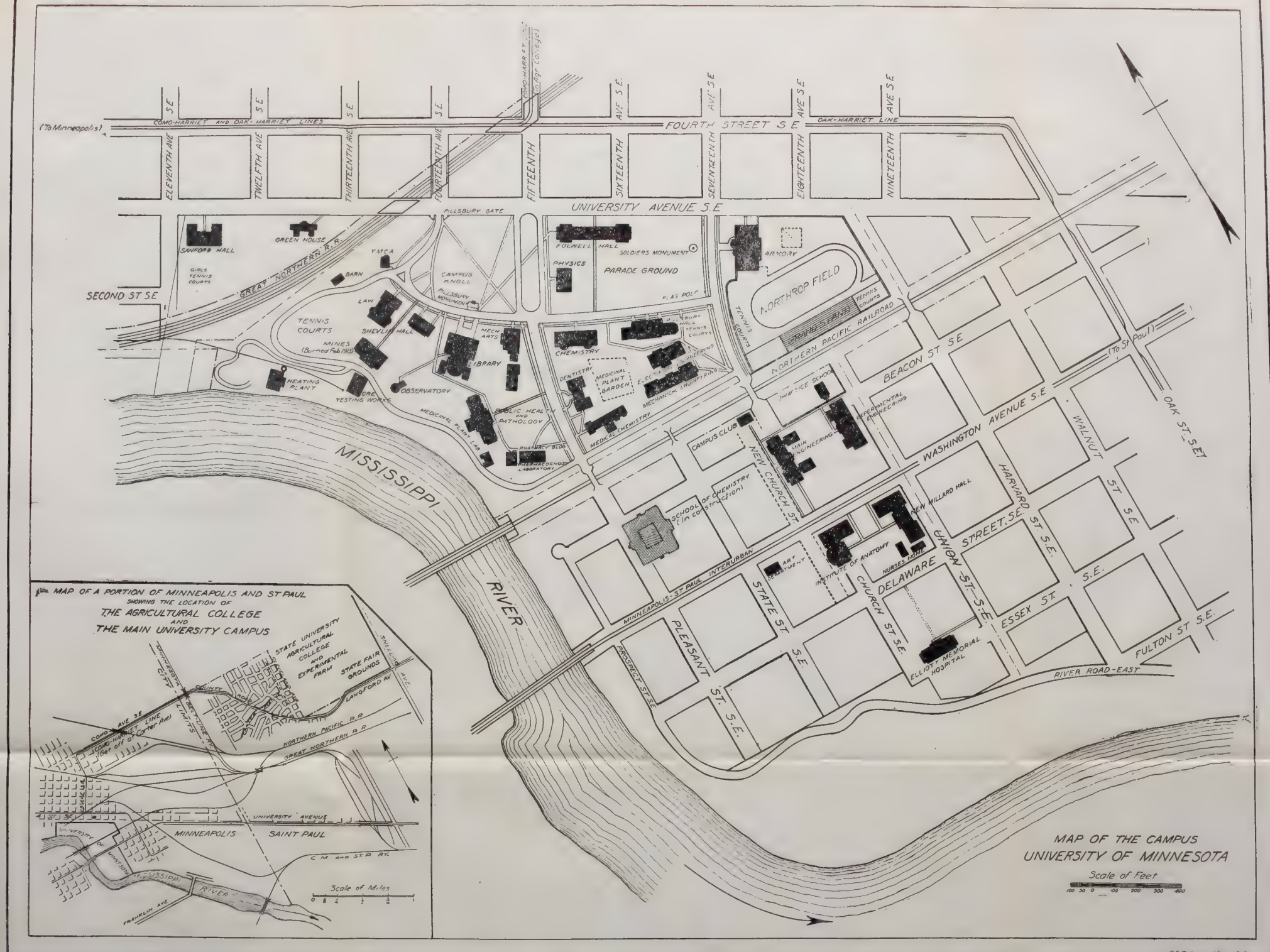
The Bulletin comprises—

Original Series. The President's Report, the Bulletin of General Information, the annual announcements of the schools, colleges, and departments of the University of Minnesota, and other formal publications of the University.

Extra Series. Announcements of departments of instruction, reports of University officers, etc.

Bulletins will be sent gratuitously, postage paid, to all persons who apply for them. In calling for bulletins, the applicant should state whether the Bulletin of General Information is desired or bulletins of certain colleges or schools of the University. Address

The REGISTRAR,
The University of Minnesota,
Minneapolis, Minnesota.


(To Minneapolis)
COMO-HARRIET AND OAK-HARRIET LINES
FOURTH STREET S.E.
OAK-HARRIET LINE
ELEVENTH AVE S.E.
TWELFTH AVE S.E.
THIRTEENTH AVE S.E.
FOURTEENTH AVE S.E.
FIFTEENTH AVE S.E.
SIXTEENTH AVE S.E.
SEVENTEENTH AVE S.E.
EIGHTEENTH AVE S.E.
NINETEENTH AVE S.E.
COMO-HARRIET LINE (To Agr. College)
UNIVERSITY AVENUE S.E.
PILLSBURY GATE
SECOND ST S.E.
SANFORD HALL
GREEN HOUSE
GIRLS TENNIS COURTS
GREAT NORTHERN R.R.
Y.M.C.A.
BARN
LAW
TENNIS COURTS
SHEVLIN HALL
MINES (Burned Feb. 1913)
HEATING PLANT
ORE TESTING WORKS
OBSERVATORY
LIBRARY
MECH. ARTS
CAMPUS KNOLL
PILLSBURY MONUMENT
FOLWELL HALL
SOLDIERS MONUMENT
PHYSICS
PARADE GROUND
ARMORY
NORTHROP FIELD
TENNIS COURTS
CINDER TRACK
TENNIS COURTS
NORTHERN PACIFIC RAILROAD
CHEMISTRY
DENTISTRY
MEDICINAL PLANT GARDEN
MECHANICAL ENGINEERING
MEDICAL CHEMISTRY
PUBLIC HEALTH AND PATHOLOGY
PHARMACY-BIOL.
PHYSIOLOGICAL LABORATORY
MEDICINAL PLANT LAB.
PHARMACY SCHOOL
BEACON ST S.E.
(To St. Paul)
OAK ST. S.E.
EXPERIMENTAL ENGINEERING
MAIN ENGINEERING
CAMPUS CLUB
NEW CHURCH ST.
WASHINGTON AVENUE S.E.
WALNUT ST. S.E.
HARVARD ST. S.E.
SCHOOL OF CHEMISTRY (In construction)
NEW MILLARD HALL
UNION STREET S.E.
ART DEPARTMENT
INSTITUTE OF ANATOMY
NURSES HOME
DELAWARE ST. S.E.
CHURCH ST. S.E.
ESSEX ST. S.E.
FULTON ST S.E.
MISSISSIPPI RIVER
MINNEAPOLIS-ST PAUL INTERURBAN
STATE ST S.E.
PLEASANT ST. S.E.
PROSPECT ST S.E.
ELLIOT MEMORIAL HOSPITAL
RIVER ROAD-EAST
MAP OF A PORTION OF MINNEAPOLIS AND ST PAUL
SHOWING THE LOCATION OF
THE AGRICULTURAL COLLEGE
AND
THE MAIN UNIVERSITY CAMPUS
STATE UNIVERSITY AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM
STATE FAIR GROUNDS
LANGFORD AV.
SNELLING AVE.
COMO AVE S.E.
COMO-HARRIET LINE (Cor. off of Cleveland Ave)
CITY LIMITS
NORTHERN PACIFIC R.R.
GREAT NORTHERN R.R.
UNIVERSITY AVENUE
MINNEAPOLIS
SAINT PAUL
C.M. AND ST.P. RY.
MISSISSIPPI RIVER
FRANKLIN AVE
Scale of Miles
MAP OF THE CAMPUS
UNIVERSITY OF MINNESOTA
Scale of Feet
O.S. Jones, Mar 1913

The University of Minnesota

THE SCHOOL OF MINES

1913-1914

BULLETIN OF THE UNIVERSITY OF MINNESOTA
VOL. XVI, NO. 14 JUNE 1913

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MINNEAPOLIS, MINN.

1913

JULY

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1914

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NOVEMBER

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DECEMBER

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UNIVERSITY CALENDAR

1913-1914

The University year covers a period of thirty-eight weeks, beginning on the second Tuesday in September. Commencement Day is always the second Thursday in June.

1913			
September	2	Tuesday	Registration closes except for new students
September	2-9	Week	Fees payable except for new students
September	8-15	Week	Supplementary entrance examinations, registration of new students, and payment of fees
September	10-16	Week	Military encampment of cadets
September	17	Wednesday	First semester begins
November	26	Wednesday	Thanksgiving recess begins 9:00 p.m.
December	1	Monday	Thanksgiving recess ends 8:00 a.m.
December	19	Friday	Christmas vacation begins 9:00 p.m.
1914			
January	6	Tuesday	Christmas vacation ends 8:00 a.m.
January	20	Tuesday	Registration for second semester closes
January	26	Monday	Final examinations begin
January	27	Tuesday	Payment of fees for second semester closes
February	4	Wednesday	Second semester begins
February	12	Thursday	Lincoln's Birthday: a holiday
February	13	Friday	First semester class reports due
April	8	Wednesday	Easter recess begins 9:00 p.m.
April	16	Thursday	Easter recess ends 8:00 a.m.
May	30	Saturday	Decoration Day: a holiday
June	1	Monday	Final examinations begin
June	6	Saturday	Second semester closes
June	7	Sunday	Baccalaureate service
June	8	Monday	Senior class day exercises
June	10	Wednesday	Alumni Day
June	11	Thursday	Forty-second Annual Commencement
June	12	Friday	Summer vacation begins

The University year for 1914-15 will begin Tuesday, September 8.

Program of Entrance Examinations, 1913-14

When entrance examinations are required this schedule will be followed:

Monday, Sept. 8	9 a.m.	Business Subjects
	2 p.m.	Manual Subjects, Domestic Art and Science, Agriculture
Tuesday, Sept. 9	9 a.m.	Astronomy, Botany, Geology, Chemistry, Physiography, Zoology, Physics, Physiology
	2 p.m.	American Government, History, Economics, Commercial Geography, History of Commerce, Economic History of England, Economic History of the United States
Wednesday, Sept. 10	9 a.m.	English
	2 p.m.	German, Greek, French, Latin, Scandinavian, Spanish
Thursday, Sept. 11	9 a.m.	Elementary Algebra
	2 p.m.	Higher Algebra
Friday, Sept. 12	9 a.m.	Plane Geometry
	2 p.m.	Solid Geometry
Thursday, June 4, 1914	9 a.m.	Elementary Algebra
	2 p.m.	Higher Algebra
Friday, June 5, 1914	9 a.m.	Plane Geometry
	2 p.m.	Solid Geometry

All candidates for examinations should report at the scheduled time in Room 112, Library Building.

Program of Supplementary Examinations

Tuesday, Sept. 9	9-12 a.m.	Mechanics and Mathematics
	2-5 p.m.	Mining Engineering Subjects
Wednesday, Sept. 10	9-12 a.m.	Chemistry
	2-5 p.m.	Drawing and Descriptive Geometry
	2-5 p.m.	Mechanical Engineering Subjects
Thursday, Sept. 11	9-12 a.m.	Metallurgical Subjects
	2-5 p.m.	Physics
Friday, Sept. 12	9-12 a.m.	Electrical Engineering Subjects
	2-5 p.m.	Geology and Mineralogy

THE UNIVERSITY

THE COLLEGE OF SCIENCE, LITERATURE, AND THE ARTS

THE COLLEGE OF ENGINEERING AND THE MECHANIC ARTS

THE DEPARTMENT OF AGRICULTURE, including—

- THE COLLEGE OF AGRICULTURE
- THE COLLEGE OF FORESTRY, including—
  - FOREST EXPERIMENT STATIONS AT ITASCA AND CLOQUET
- THE CENTRAL SCHOOL OF AGRICULTURE, UNIVERSITY FARM, including—
  - THE DAIRY SCHOOL
  - THE SHORT COURSE FOR FARMERS
  - TEACHERS' SUMMER TRAINING SCHOOL
  - THE SCHOOL OF TRACTION ENGINEERING
- THE NORTHWEST SCHOOL OF AGRICULTURE, CROOKSTON
- THE WEST CENTRAL SCHOOL OF AGRICULTURE, MORRIS
- THE EXPERIMENT STATIONS, including—
  - THE MAIN STATION, ST. ANTHONY PARK
  - THE NORTHWEST EXPERIMENT STATION, CROOKSTON
  - THE NORTH CENTRAL EXPERIMENT STATION, GRAND RAPIDS
  - THE WEST CENTRAL EXPERIMENT STATION, MORRIS
  - THE NORTHWEST DEMONSTRATION FARM AND EXPERIMENT STATION, DULUTH
  - THE SOUTHEAST DEMONSTRATION FARM AND EXPERIMENT STATION, WASECA
  - THE FRUIT BREEDING FARM, ZUMBRA HEIGHTS
- AGRICULTURAL EXTENSION

THE LAW SCHOOL

THE MEDICAL SCHOOL, including—

- THE SCHOOL FOR NURSES

THE COLLEGE OF DENTISTRY

THE COLLEGE OF PHARMACY

THE SCHOOL OF MINES, including—

- MINNESOTA SCHOOL OF MINES EXPERIMENT STATION

THE SCHOOL OF ANALYTICAL AND APPLIED CHEMISTRY

THE COLLEGE OF EDUCATION

THE GRADUATE SCHOOL

THE BOARD OF REGENTS

The Hon. JOHN LIND, Minneapolis, President of the Board - - 1914
GEORGE EDGAR VINCENT, Minneapolis - - - - - *Ex-Officio*
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The Governor of the State
The Hon. C. G. SCHULZ, St. Paul - - - - - - *Ex-Officio*
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The Hon. B. F. NELSON, Minneapolis - - - - - - 1916
The Hon. PIERCE BUTLER, St. Paul - - - - - - - 1916
The Hon. FRED B. SNYDER, Minneapolis - - - - - - 1916
The Hon. W. J. MAYO, Rochester - - - - - - - 1919
The Hon. MILTON M. WILLIAMS, Little Falls - - - - - 1919

EXECUTIVE OFFICERS

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GEORGE F. JAMES, Ph.D., Dean of the College of Education
GUY STANTON FORD, Ph.D., Dean of the Graduate School
MARGARET SWEENEY, Ph.D., Dean of Women

THE SCHOOL OF MINES

FACULTY

GEORGE EDGAR VINCENT, Ph.D., LL.D., President 1005 5th St. S. E.
CYRUS NORTHROP, LL.D., President, Emeritus 519 10th Ave. S. E.
WILLIAM R. APPLEBY, M.A., Dean and Professor of Metallurgy 928 5th St. S. E.
*CHARLES E. VAN BARNEVELD, B.A.Sc., E.M., Professor of Mining Engineering 2110 Aldrich Ave. S.
CHARLES W. BENTON, Litt.D., Professor of Romance Languages 516 9th Ave. S. E.
PETER CHRISTIANSON, B.S., E.M., Professor of Metallurgy 217 Union St. S. E.
ELTING H. COMSTOCK, M.S., Professor of Mechanics and Mathematics 1416 7th St. S. E.
WILLIAM H. EMMONS, Ph.D., Professor of Mineralogy and Geology 217 The Leamington
JOHN J. FLATHER, Ph.B., M.M.E., Professor of Mechanical Engineering 315 11th Ave. S. E.
GEORGE B. FRANKFORTER, Ph.D., Professor of Chemistry 525 E. River Road
WILLIAM H. KAVANAUGH, M.E., Professor of Experimental Engineering 124 State St. S. E.
WILLIAM H. KIRCHNER, B.S., Professor of Drawing and Descriptive Geometry 722 10th Ave. S. E.
EDWARD P. MCCARTY, E.M., Professor of Mining 112 Church St. S. E.
JOHN G. MOORE, B.A., Professor of German 2810 University Ave. S. E.
LEVI B. PEASE, M.S., Professor of Metallurgy 1070 16th Ave. S. E.
GEORGE D. SHEPARDSON, M.A., M.E., D.Sc., Professor of Electrical Engineering 717 E. River Road
CHARLES F. SIDENER, B.S., Professor of Chemistry 1320 5th St. S. E.
JOSEPH M. THOMAS, Ph.D., Professor of Rhetoric 623 14th Ave. S. E.
JOHN ZELENY, Ph.D., Professor of Physics 712 10th Ave. S. E.
FRANCIS C. FRARY, Ph.D., Assistant Professor of Chemistry 305 Walnut St. S. E.
JULES T. FRELIN, B.A., Assistant Professor of Romance Languages 112 Church St. S. E.
FRANK F. GROUT, M.S., Assistant Professor of Geology and Mineralogy 2150 Carter Ave., St. Paul
SAMUEL L. HOYT, E.M., Assistant Professor of Metallurgy

*On leave of absence 1913-16.

MERTON S. KINGSTON, E.M., Assistant Professor of Mining
608 Oak St. S. E.
EDWIN M. LAMBERT, M.E., Assistant Professor of Mechanics and Mathematics 1086 12th Ave. S. E.
WILLIAM T. RYAN, E.E., Assistant Professor of Electrical Engineering
3228 4th St. S. E.
FREDERICK W. SARDESON, Ph.D., Assistant Professor of Paleontology
414 Harvard St. S. E.
S. CARL SHIPLEY, B.S., M.E., Assistant Professor of Machine Construction
1517 E. River Road
CHARLES F. SHOOP, B.S., Assistant Professor of Experimental Engineering 108 Beacon St. S. E.

INSTRUCTORS

OLIVER BOWLES, M.A., Instructor in Mineralogy and Geology
321 19th Ave. S. E.
LILLIAN COHEN, M.S., Instructor in Chemistry 415 E. 14th St.
EDWARD W. DAVIS, B.S., Instructor in Mechanics and Mathematics
112 Church St. S. E.
ROBERT W. FRENCH, B.S., Instructor in Drawing 1018 16th Ave. S. E.
A. WALFRED JOHNSTON, M.A., Instructor in Geology
417 Union St. S. E.
ERVIN W. MCCULLOUGH, E.M., Instructor in Mining
90 Malcolm Ave. S. E.
FRANKLIN R. MCMILLAN, C.E., Instructor in Experimental Engineering
321 Oak St. S. E.
EDMUND NEWTON, E.M., Instructor in Metallurgy 32 Spruce Place
PETER E. PETERSON, Instructor in Foundry Practice
3709 Clinton Ave.
EARL PETTIJOHN, M.S., Instructor in Chemistry 3012 James Ave. S.
WARREN T. POWELL, M.A., Instructor in Rhetoric 215 Harvard St. S. E.
EDWARD P. QUIGLEY, Instructor in Forge Work 2923 Chicago Ave.
WILLIAM H. RICHARDS, Instructor in Carpentry 1423 W. 27th St.
FRANK B. ROWLEY, B.S., M.E., Instructor in Drawing
217 Beacon St. S. E.
JAMES COXE SANDERSON, Ph.D., Instructor in Physics
1307 6th St. S. E.
L. L. THURSTONE, M.E., Instructor in Drawing 320 Walnut St. S. E.
EDGAR K. SOPER, B.A., Instructor in Economic Geology
417 Union St. S. E.
WOLDEMAR M. STERNBERG, B.S.Chem., Instructor in Chemistry
1203 7th St. S. E.
STERLING TEMPLE, Ph.D., Instructor in Chemistry
1758 Blair St., St. Paul

WINIFRED GREGORY, Librarian

ADMISSION

The courses leading to the degrees of Engineer of Mines and Metallurgical Engineer may be completed in either four or five years. The course leading to the degree of Engineer of Mines (in Geology) may be completed in five years.

Students may enter the School of Mines without preparation in Higher Algebra and Solid Geometry. Such students must enter the five-year courses.

Students who enter the four-year courses with Higher Algebra and Solid Geometry must pass the entrance examinations in Mathematics given by the School. State High-School Board certificates will be accepted for all subjects except Mathematics.

It is recommended that students who come poorly prepared in Mathematics enter the five-year courses.

Examinations for admission in subjects other than Mathematics will be held at the beginning of the year. Examinations in Mathematics are held in June and September. See calendar and program of examinations.

No senior will be registered for the first semester's work after September 9, 1913.

No other students will be registered for the first semester's work after September 27, 1913, nor any student for the second semester's work after February 14, 1914.

All applicants should present themselves to the Chairman of the Enrollment Committee, Room 4, Main Engineering Building, who will furnish them with application blanks and directions covering examinations and registration.

Women will not be admitted to any course offered in the School of Mines.

GENERAL REGULATIONS GOVERNING ADMISSION

I. Students will be admitted to the freshman class on passing the regular entrance examinations.

II. No student will be admitted if conditioned in more than three half-year subjects, or their equivalent. No conditions, however, in entrance Mathematics shall be allowed except upon special permission of the Department of Mathematics.

III. Graduates of any Minnesota State High School will be admitted to the five-year courses without examination, or to the four-year courses with examination in Mathematics, provided:

(1) That the school maintain a full four-year course of high-school work.

(2) That the applicant present to the Registrar the principal's certificate showing the satisfactory completion of all studies required for admission to the desired University course.

IV. Graduates of Minnesota State High Schools who are deficient in not more than three half-year subjects or their equivalent, may be excused from entrance examinations in such subjects as the Enrollment Committee may decide upon; such candidates should present themselves to the Committee not later than Tuesday of examination week.

V. Graduates of Minnesota State High Schools whose principal's certificate shows them to be deficient in more than three half-year subjects or their equivalent, even though they have made such additional preparation as they deem necessary, must take, nevertheless, the regular entrance examination in all subjects, as provided in Sections I and II, unless excused by vote of the Faculty; and persons wishing to present reasons for such excuse should report to the Enrollment Committee not later than Tuesday of examination week.

VI. Graduates of the Advanced Courses of Minnesota Normal Schools will be admitted upon the same terms as graduates of State High Schools.

VII. Any Minnesota high school or academy not under supervision of the State High-School Board, but requiring for graduation a four years' course, exclusive of the common school branches, conforming essentially in distribution of time to the entrance requirements of at least one of the University courses, will, upon application, be inspected by a committee, and, after favorable recommendation, may be accredited by the Faculty in all respects as are the State High Schools, provided:

(1) That the school be open to inspection at any time by the University.

(2) That it take such supplementary examinations as may be prescribed from time to time.

VIII. Graduates from schools in other states, whose diplomas admit to reputable colleges in the state in which the school is located, will be received subject to the regulations that apply to graduates of Minnesota State High Schools.

IX. Applicants coming from schools not included in any of the above classes must take the regular entrance examinations or present State High-School Board certificates.

In all cases the Faculty reserves the right to require a student to take supplementary examinations if he does not sustain himself creditably in his course.

The Enrollment Committee will meet every day during the week commencing Tuesday, September 9, in Main Engineering Building, Room 4, at 9:00 a.m.

REQUIREMENTS FOR ADMISSION TO THE FIVE-YEAR COURSES

The term *unit* means not less than five recitations of forty minutes each per week for a period of thirty-six weeks. In manual subjects and

kindred courses, it means the equivalent of ten recitation periods per week for thirty-six weeks.

Required Subjects:

English.....*four units
Elementary Algebra.....one unit
Plane Geometry.....one unit
Electives.....nine units

REQUIREMENTS FOR ADMISSION TO THE FOUR-YEAR COURSES

Required Subjects:

English.....*four units
Elementary Algebra.....one unit
Higher Algebra.....one-half unit
Plane Geometry..... one unit
Solid Geometry.....one-half unit
Electives.....eight units

Electives. (Eight units must be selected from this list for the four-year courses and nine units for the five-year courses.)

Latin
- Grammar, one unit
- Caesar, four books, one unit
- Cicero, six orations, one unit
- Virgil, six books, one unit

Greek
- Grammar, one unit
- Anabasis, four books, one unit

German
- Grammar, one unit
- Literature, one to three units

French
- Grammar, one unit
- Literature, one to three units

Spanish
- Grammar, one unit
- Literature, one unit

Scandinavian Languages
- Grammar, one unit
- Literature, one unit

History
- Ancient, to Charlemagne, one unit
- Modern, from Charlemagne, one unit
- English, one-half unit
- Senior American, one-half unit

*Three units will satisfy the English requirement when the applicant presents four units in one foreign language. In this case a sufficient number of electives must be presented to make a total of fifteen entrance units.

American Government, one-half unit
Elementary Economics, one-half unit
History of Commerce, one-half unit
Commercial Geography, one-half or one unit
Physics, one unit
Chemistry, one unit
Botany, one-half or one unit
Zoology, one-half or one unit
Astronomy, one-half unit
Geology, one-half unit
Physiography, one-half unit

Not more than four units are allowed in the following vocational subjects, including Business Subjects, Manual Subjects, and Agriculture.

Business Subjects
- Business Law, one-half unit
- Business Arithmetic, one-half unit
- Elementary Bookkeeping, one-half unit
- Advanced Bookkeeping and Business Practice, one unit
- Stenography and Typewriting, two units

Manual Subjects
- Freehand Drawing, two units
- Mechanical Drawing, two units
- Shop Work, two units
- Modeling and Wood Carving, one unit

Agriculture

One to four units from schools receiving special state aid for Agriculture, and also from other schools in which such course in Agriculture is approved by the State High School Board, as fast as the said schools are prepared to offer work in Agriculture.

DESCRIPTION OF SUBJECTS ACCEPTED FOR ADMISSION

A description of the subjects accepted for admission to the University will be found in the Bulletin of General Information, which will be sent to any address upon application to the Registrar, The University of Minnesota, Minneapolis, Minnesota.

ADVANCED STANDING

The University accepts records from other colleges for credit to advanced standing. Such records are accepted as far as they are equivalent to the work in this University, subject to the approval of the departments concerned. In bringing records from other institutions, the certificates must be on the official blanks of the institution granting the certificate, and should show:

1. The subjects studied and ground covered.
2. The time spent upon each subject.
3. In case of laboratory subjects, a concise statement of work done.
4. The result. It is sufficient to state the subjects were creditably completed.

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee.

DAILY ROUTINE

The daily session is divided into eight recitation periods of fifty minutes each, four in the morning and four in the afternoon. The morning session begins at 8:00 and closes at 12:00 o'clock; the afternoon session extends from 1:00 o'clock until 5:50 o'clock. A general assembly of the Faculty and students is held at 12:00 o'clock on Tuesdays, Thursdays, and Saturdays, at which there are brief and simple religious exercises. The noon hour extends from 12:00 to 1:00 o'clock. Work extends through six days of the week.

EXAMINATIONS

Students failing to receive a semester mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his yearly average in all subjects and present himself for supplementary examinations, according to the program given on page iv.

No other supplementary examination will be given. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to receive a semester mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The Faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

All students who voluntarily register for Military Drill shall be required to drill the entire year and be subject to the same rules and reg-

ulations as other cadets. Such students must receive credit or honorable dismissal from the department before graduating.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination at the end of the first or second semester will be given zero on the examinations.

Students whose absences in either semester exceed four weeks in the aggregate are not permitted to take examinations without special permission of the Faculty.

A fee of five dollars per subject is required for each special examination.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

GRADUATION

Students completing courses of study to the satisfaction of the Faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the Faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations held at the end of the second semester. Irregular attendance will debar a student from entering all final examinations.

THESES

The thesis work is intended to bring in review and connect the work in Mining and Metallurgy, Geology and Mineralogy, Mechanical and Electrical Engineering, Mathematics and Mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the re-opening of Field Work at the School of Mines, Tuesday, September 9, 1913, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the School.

SPECIAL INFORMATION

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M. (Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four or five years, and vice versa, provided such candidate completes an additional year's work at the School and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and the Mechanic Arts, and in the School of Analytical and Applied Chemistry, who contemplate taking a degree in this School after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

SUMMARY OF EXPENSES

FIRST YEAR—FIVE-YEAR COURSES

*Incidental fee	$55.00
Books (estimated)	20.00
Note-books and supplies (estimated)	5.00

FRESHMAN YEAR

*Incidental fee	$55.00
Books (estimated)	25.00
Draughting instruments (estimated)	15.00
Note-books and supplies (estimated)	5.00

SOPHOMORE YEAR

*Incidental fee	$55.00
Field work (May 1 to July 1) Surveying / Geological	100.00 to 150.00
Books (estimated)	15.00
Note-books and supplies (estimated)	5.00

JUNIOR YEAR

*Incidental fee	$55.00
Field work (May 1 to July 1) Metallurgy / Mining	175.00 to 250.00
Books (estimated)	30.00
Note-books and supplies (estimated)	5.00

*This fee covers all laboratory expenses.

SENIOR YEAR

*Incidental fee	$55.00
Books (estimated)	30.00
Note-books and supplies (estimated)	5.00

In addition to the first semester incidental fee a deposit fee of $5.00 is required to cover such items as annual rental of post-office box, locker key deposit, condition examination fee, and late registration or late payment of fees. The unused balance will be returned at the end of the year.

REGISTRATION

Students having matriculated in previous years are required to indicate registration on proper blank not later than September 2. Fees must be paid in full on or before September 9.

For the second semester, registration must be indicated on or before January 20, and fees must be paid on or before January 27.

A penalty fee of one dollar will be charged all students who do not register or pay fees within the time specified, and, after one week, a fee of twenty-five cents per day for each day's delay will be added. The Registrar will send proper blanks to all students who were in college the previous year, on or before August 20. Students who fail to receive blanks at that date should call for them.

ORGANIZATION

The organization of the School of Mines dates back to 1889, when the General Faculty of the University recommended its establishment to the Board of Regents. In 1891 the Legislature of the State of Minnesota voted an appropriation for establishing and equipping the School. Two annual appropriations have since been made for its support. The Legislature of 1901 appropriated $47,500 for a new School of Mines Building. In 1903 the Legislature appropriated $25,000 for completing and equipping the School of Mines Building, and in 1905 an additional sum was provided for equipment.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the State, to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates

*This fee covers all laboratory expenses.

for the Tax Commission and to do such other work along the lines above outlined as may be requested by other state departments. Co-operation has been effected with the Minnesota Geological Survey and the School of Chemistry.

The Experiment Station is prepared to assist citizens interested in these lines of work; to assay specimens of ore, rocks, clays, and minerals found within the State free of charge.

In submitting samples the sender must state the exact location where each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the Office of the Station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, The University of Minnesota, Minneapolis, Minnesota.

LOCATION

The University of Minnesota is located in the city of Minneapolis, on the east bank of the Mississippi River. The School of Mines has its buildings and laboratories on the same ground. Students of the School of Mines have, therefore, all the opportunities afforded by a large university.

Minneapolis is surrounded by, and is in direct communication with, several important mining and smelting districts. As the city is a railroad center adequate transportation facilities are available.

FIELD WORK

Field work is conducted at the iron mines in the northern part of this State, in the copper and iron regions of Michigan, in the mines and smelters of Montana, Colorado, Utah, Arizona, and California, and in the coal mines of Pennsylvania.

At least one of these districts will be visited by each class, affording splendid opportunities for study and observation.

The field work in Mining and Metallurgy consists of two trips, one at the close of the sophomore year and one at the close of the junior year. For details, see pages 20 and 25.

Students must deposit with the Cashier, at least two weeks before time set for departure of class, a sum sufficient to cover following expense items:

1st. Board and lodging.
2d. Necessary mine supplies.

Transportation and incidental expenses are not included in the above items and must be met individually.

A statement of expenditures will be rendered at the close of the work and any balance existing will be refunded.

The amount of deposit required will vary according to the locality visited, and will be announced each year when arrangements for the trip are completed.

THE ELLIOT SCHOLARSHIP LOAN FUND

To fulfill the wish of the late Dr. A. F. Elliot to aid young men who find their efforts to obtain a practical education embarrassed through lack of means, the sum of $5,000 was placed in the hands of the Board of Regents as a scholarship fund. The income from this fund is loaned students in the School of Mines on the following conditions: the financial needs of the applicant, his scholarship, moral character, enthusiasm shown in his work, and promise of usefulnesss in his profession. When money is available, it may be loaned to pay the expenses of worthy students during sickness. The loans are to be repaid, without interest, at the earliest convenience of the recipients.

LIBRARY

The library consists of about six thousand five hundred volumes. This number represents only those works that treat directly of mining, geological, and metallurgical subjects.

The School has a complete set of the leading mining and metallurgical journals and other similar books of reference. The leading periodicals are accessible to all. Constant references in lectures compel the student to keep himself well-informed as to the latest methods, machinery, and changes in practice going on in his special line of work.

In addition to the above, many thousand volumes on allied subjects complete a most valuable working and reference library. A card index is kept of all articles of value and interest appearing in the leading periodicals. An attendant is always in charge.

PHOTOGRAPHY

Photographs of surface and underground appliances, metallurgical plants, copies of drawings, and other photographs are indispensable to the study of Mining and Metallurgy. With the report of his field work every student is expected to present photographs, as well as sketches, of

various objects under consideration. There is also a very complete set of lantern slides illustrating the principal methods of underground workings and metallurgical plants, at home and abroad. Several hundred slides have been made in the department's laboratory which bear directly on the work done in Minnesota and the neighboring northwest. Many valuable photographs are constantly being made. Blue prints of these are given students as illustrations. Much time, usually spent in making sketches and diagrams, is thus saved.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thorough courses in Mechanics, Mathematics, Physics, and Chemistry.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine if it has value for treatment. (d) *Mining Engineering*—to furnish material for treatment. (e) *Ore Testing*—to determine best methods of treatment. (f) *Ore Dressing*—furnishing products for metallurgical treatment. (g) *Metallurgy*—smelting and refining ores and ore dressing products; reduction to metals.

COURSES IN MINING ENGINEERING

COURSES LEADING TO THE DEGREE OF E.M.

FIRST YEAR—FIVE-YEAR COURSES

First Semester

Chemistry 1, General, six hours
Mathematics 1, Algebra, four hours
Mathematics 3, Computation and Mensuration, three hours
Mechanical Engineering 3, Foundry Practice, six hours
Rhetoric 15, four hours
Spanish 11, Beginning, three hours

Second Semester

Chemistry 1, General, six hours
Mathematics 2, Solid Geometry and Mensuration, three hours
Mathematics 4, Mine Accounting, three hours
Mechanical Engineering 2, Blacksmithing, six hours (nine weeks)
Mechanical Engineering 1, Carpentry, six hours (nine weeks)
Rhetoric 15, four hours
Spanish 11, Beginning, three hours

FRESHMAN YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 2, General and Qualitative Analysis, five hours
Drawing 11, Engineering Drawing, ten hours
Mathematics 5, Algebra and Trigonometry, six hours
Mineralogy 1, General Mineralogy, eight hours

Second Semester

Chemistry 3, Qualitative Analysis, seven hours
Drawing 12, Engineering Drawing, eight hours
Mathematics 6, Trigonometry and Analytic Geometry, six hours
Metallurgy 1, Assaying, twelve hours
Mineralogy 2, Physical Mineralogy, four hours

SOPHOMORE YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 4, Quantitative Analysis, seven hours
Drawing 13, Descriptive Geometry, two hours
Mathematics 7, Analytic Geometry and Calculus, five hours
Metallurgy 2, General and Iron, three hours
Mining 1, Mine Surveying, three hours
Physics 1, General, three hours
Physics 2, Laboratory Practice, two hours

Second Semester

Chemistry 5, Volumetric Analysis, seven hours
Drawing 14, Drafting, four hours

Geology 3, Elements of Geology, three hours
Geology 9, Rock Study, four hours
Mathematics 8, Calculus, three hours
Metallurgy 3, Wrought Iron and Steel, three hours
Mining 1, Mine Surveying, three hours
Mining 2, one hour
Physics 3, General, three hours
Physics 4, Laboratory Practice, two hours
Field Work. Months of May, June, July, and August
Mining 3, Surveying, beginning about May 1
Geology 3a, beginning about June 15
Underground Mining Work, beginning about July 1

JUNIOR YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Experimental Engineering 1, Strength of Materials, four hours
Geology 4, Historical and Economic Geology, three hours
Mechanics 9, five hours
Mechanics 11, Mine Plant, six hours
Metallurgy 4, Base Metals, four hours
Mining 4, five hours

Second Semester

Experimental Engineering 2, Steam Laboratory, four hours
Geology 10, Petrology, four hours
Mechanics 10, six hours
Metallurgy 5, Precious Metals, four hours
Mining 5, five hours
Mining 6, three hours
Mining 7, Ore Dressing, five hours
Mining 8, Mine Mapping, six hours
Field Work. Months of May, June, July, and August
Metallurgy 10, beginning about May 1
Mining 9, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 14, Special Problems, seven hours
Electrical Engineering 4, Electric Power, five hours
Geology 12, Ore Deposits, four hours
Mechanics 13, Water Power, five hours
Mechanics 15, Engineering Construction, five hours
Metallurgy 6, Ore Testing, ten hours
Mining 10, Mining Engineering, five hours
Mining 13, Thesis, two hours

Second Semester

Chemistry 11a, Iron and Steel Analysis, seven hours
Experimental Engineering 5, Experimental Laboratory, four hours
Geology 13, Special Problems, four hours

Mechanics 16, Mine Plant Design, six hours
Mining 11, Mining Engineering, five hours
Mining 12, Designs and Specifications, eight hours
Mining 13, Thesis, four hours

COURSES LEADING TO THE DEGREE OF E.M. (GEOLOGY)

FIRST YEAR

First Semester

Chemistry 1, General, six hours
Drawing 11, Engineering Drawing, ten hours
French 1 or 3, three hours
or
German 1 or 4, three hours
Mathematics 1, Algebra, four hours
Rhetoric 15, four hours

Second Semester

Chemistry 1, General, six hours
Drawing 12, Engineering Drawing, eight hours
French 1 or 3, three hours
or
German 1 or 4, three hours
Mathematics 2, Solid Geometry and Mensuration, three hours
Rhetoric 15, four hours

FRESHMAN YEAR

First Semester

Chemistry 2, General and Qualitative Analysis, five hours
French 2 or 5, three hours
or
German 3 or 7, three hours
Mathematics 5, Algebra and Trigonometry, six hours
Mineralogy 1, General Mineralogy, eight hours

Second Semester

Chemistry 3, Qualitative Analysis, seven hours
French 2 or 5, three hours
or
German 3 or 7, three hours
Mathematics 6, Trigonometry and Analytic Geometry, six hours
Metallurgy 1, Assaying, twelve hours
Mineralogy 2, Physical Mineralogy, four hours

SOPHOMORE YEAR

First Semester

Chemistry 4, Quantitative Analysis, seven hours
Drawing 13, Descriptive Geometry, two hours
Mathematics 7, Analytic Geometry and Calculus, five hours
Mineralogy (Advanced), three hours
Mining 1, Mine Surveying, three hours

Physics 1, General, three hours
Physics 2, Laboratory Practice, two hours

Second Semester

Chemistry 5, Volumetric Analysis, eight hours
Drawing 14, Drafting, four hours
Geology 3, Elements of Geology, three hours
Geology 9, Rock Study, four hours
Mathematics 8, Calculus, three hours
Metallurgy, three hours
Mining 1, Mine Surveying, three hours
Mining 2, one hour
Physics 3, General, three hours
Physics 4, Laboratory Practice, two hours
Field Work. Months of May, June, July, and August
Mining 3, Surveying, beginning about May 1
Geology 3a, beginning about June 15
Special Geological Field Work, beginning about July 1

JUNIOR YEAR

First Semester

Geology 4, Historical and Economic Geology, three hours
Mechanics 9, five hours
Mining 4, five hours
Geology 14, Paleontology, three hours
Electives, ten hours

Second Semester

Geology 10, Petrology, four hours
Mechanics 10, six hours
Mining 5, five hours
Mining 6, three hours
Mining 7, Ore Dressing, five hours
Mining 8, Mine Mapping, six hours
Geology 15, Paleontology (Practice), nine hours
Field Work. Months of May, June, July, and August
Mining 9, beginning about May 15
Underground Mining Work, beginning about June 1
Practical Geology, beginning about July 1

SENIOR YEAR

First Semester

Geology 12, Ore Deposits, four hours
Geology of Lake Superior District, five hours
General and Mining Law, three hours
Mechanics 13, Water Power, five hours
Mining 10, Mining Engineering, five hours
Thesis, ten hours

Second Semester

Geology 13, Special Problems, four hours
Geology 13a, Seminar in Ore Deposits, three hours

Geology of Western Mining Districts, five hours
Mining 11, Mining Engineering, five hours
Electives, five hours
Thesis, ten hours

DEPARTMENT OF MINING ENGINEERING

Mining Engineering extends through the sophomore, junior, and senior years. The subjects given, together with the sequence necessary, are treated in the accompanying outline of the course.

In the senior year, problems in hoisting, hauling, pumping, ventilation, and similar subjects become an important part of the work.

DESIGNS AND SPECIFICATIONS

The student makes, in connection with his thesis work, working drawings of mine cars, skips, and other parts of mine equipment that are usually designed and made at the mine.

MINE SURVEYING

The work in Surveying is given in the sophomore year and is designed solely for mining engineers.

The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi or Vermilion Range. The exact location will be announced in March of each year.

The students will be divided into squads of two to four. Each squad must provide itself with a 6-foot steel tape graduated to hundredths. The duration of the course will be seven weeks (5½ days of 8 hours each constitute a week). Each student will be required to complete satisfactorily the following exercises and surveys:

1. Chaining and taping
2. Compass work
3. Adjustment and use of wye and dumpy levels
4. Adjustment of mining transit
5. Reading angles
6. Traverse with transit and steel tape
7. Azimuth traverse with stadia
8. Determination of meridian, latitude, and time by solar and stellar observations
9. Survey of mining claim according to the regulations of the U. S. Government
10. Measurement of earthwork

11. Laying out railroad tangents, curves, and crossings
12. Exercises in plane table work and geological surveying
13. The survey of a mine.

A full equipment of surveying instruments of the latest and best makes is furnished to each squad for this work.

This is followed by a course in Mine Mapping during the second semester of junior year.

Students who furnish satisfactory evidence of proficiency in this work may be given credit therefor. The department, however, reserves the right in any case to require such students to take a theoretical or a practical examination or both.

FIELD WORK IN MINING

Sophomore Year

After the close of the field work in Geology (last two weeks in June), members of the sophomore class are required to engage for six weeks in underground mining work on the Minnesota or Michigan iron ranges, for which they may receive wages.

Junior Year

Upon termination of the junior field work in Metallurgy (about May fifteenth), the members of the junior class, who are candidates for the degree of Engineer of Mines, are required to devote two weeks to the study of mine plant and mine operation under the direction of the department. This work will be given in one of the leading western metal mining districts, exact location to be announced in April of each year. Thereafter, during the months of June, July, and August, the student is required to spend at least eight weeks in actual underground mining work in the West, for which he may receive wages. The department will render all possible assistance in locating students in the camps of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must in person submit this diary to the department on the date of the reopening of field work. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 9, 1913. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering Field Work in Mine Mapping, Mining, and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned.

The program covering this work is as follows: Metallurgy, September 9-16 inclusive; Mining, September 17-29.

On September 29 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to

scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before September 29. These reports shall become the property of the School.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reason, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

ORE DRESSING

The lectures and recitations in Ore Dressing extends through the second semester of the junior year, and comprise the detailed study of ore dressing and concentrating machinery, together with the study of typical combinations of dressing machines as found in the several mining districts of the United States.

In connection with the theoretical work, the ore dressing and testing plant of the School is utilized for practical illustrations.

COURSES IN METALLURGY

COURSES LEADING TO THE DEGREE OF MET. E.

FIRST YEAR—FIVE-YEAR COURSES

First Semester

Chemistry 1, General, six hours
Mathematics 1, Algebra, four hours
Mathematics 3, Computation and Mensuration, three hours
Mechanical Engineering 3, Foundry Practice, six hours
Rhetoric 15, four hours
Spanish 11, Beginning, three hours

Second Semester

Chemistry 1, General, six hours
Mathematics 2, Solid Geometry and Mensuration, three hours
Mathematics 4, Mine Accounting, three hours
Mechanical Engineering 2, Blacksmithing, six hours (nine weeks)
Mechanical Engineering 1, Carpentry, six hours (nine weeks)
Rhetoric 15, four hours
Spanish 11, Beginning, three hours

FRESHMAN YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 2, General and Qualitative Analysis, five hours
Drawing 11, Engineering Drawing, ten hours
Mathematics 5, Algebra and Trigonometry, six hours
Mineralogy 1, General Mineralogy, eight hours

Second Semester

Chemistry 3, Qualitative Analysis, seven hours
Drawing 12, Engineering Drawing, eight hours
Mathematics 6, Trigonometry and Analytic Geometry, six hours
Metallurgy 1, Assaying, twelve hours
Mineralogy 2, Physical Mineralogy, four hours

SOPHOMORE YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 4, Quantitative Analysis, seven hours
Drawing 13, Descriptive Geometry, two hours
Mathematics 7, Analytic Geometry and Calculus, five hours
Metallurgy 2, General and Iron, three hours
Mining 1, Mine Surveying, three hours
Physics 1, General, three hours
Physics 2, Laboratory Practice, two hours

Second Semester

Chemistry 5, Volumetric Analysis, seven hours
Drawing 14, Drafting, four hours

Geology 3, Elements of Geology, three hours
Geology 9, Rock Study, four hours
Mathematics 8, Calculus, three hours
Metallurgy 3, Wrought Iron and Steel, three hours
Mining 1, Mine Surveying, three hours
Mining 2, one hour
Physics 3, General, three hours
Physics 4, Laboratory Practice, two hours
Field Work. Months of May, June, July, and August
Mining 3, Surveying, beginning about May 1
Geology 3a, beginning about June 15
Underground Mining Work, beginning about July 1

JUNIOR YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Experimental Engineering 1, Strength of Materials, four hours
Geology 4, Historical and Economic Geology, three hours
Mechanics 9, five hours
Mechanics 11, Mine Plant, six hours
Metallurgy 4, Base Metals, four hours
Mining 4, five hours

Second Semester

Experimental Engineering 2, Steam Laboratory, four hours
Geology 10, Petrology, four hours
Mechanics 10, six hours
Metallurgy 5, Precious Metals, four hours
Mining 5, five hours
Mining 6, three hours
Mining 7, Ore Dressing, five hours
Mining 8, Mine Mapping, six hours
Field Work. Months of May, June, July, and August
Metallurgy 10, beginning about May 1
Mining 9, beginning about May 15
Smelter Work, beginning about June 1

SENIOR YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 14, Special Problems, seven hours
Electrical Engineering 4, Electric Power, five hours
Mechanics 13, Water Power, five hours
Mechanics 15, Engineering Construction, five hours
Metallurgy 6, Ore Testing, ten hours
Metallurgy 7, Special Problems, eight hours
Metallurgy 8, Electro-Metallurgy, three hours

Second Semester

Chemistry 22, Electro-Chemical Analysis, five hours
Chemistry 11a, Iron and Steel Analysis, seven hours
Experimental Engineering 5, Experimental Laboratory, four hours

Mechanics 18, Mill and Smelter Design, six hours
Metallurgy 9, Metallography, six hours
Metallurgy 11, Thesis, ten hours

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use.

The practical work consists in visits to smelting and refining works which are accessible. The work in Metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces' fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags are shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their reports in detail. This work is offered to students completing the necessary courses in Mineralogy and Chemistry.

ORE TESTING

The lectures treat of the use and purposes of all the machinery connected with the subject, supplemented by detailed drawings.

There are complete testing works connected with the department where the student may see the working of, and handle for himself, crushers, rolls, Huntington mill, concentrating machinery, such as vanners, buddles, jigs, pan for amalgamation, settlers, reverberatory furnaces for oxidizing and oxidizing-chloridizing roasts, leaching and chlorination plants, as well as sizing apparatus and hydraulic separators. Sufficiently large amounts of ore are given to make the necessary tests upon the different machines and the students report the best method of treatment. The first semester of the senior year is devoted to instruction and laboratory work, and is required of students both in Mining and Metallurgy.

The ore-testing works meet educational, as well as commercial, needs.

Educational.—The ore-testing plant acquaints the student with the construction and manipulation of the principal typical machines used in the leading ore-dressing establishments of the country. It is here that students in Mining and Metallurgical Engineering get the requisite practical experience. They handle all machines and operate on sufficiently large amounts of material to determine the methods best suited to a given ore to extract the largest amount of metal with the least possible loss.

Commercial.—Ore-testing works are an important factor in mining and metallurgical projects. The commercial object is to determine the best method of treating a given ore so as to yield the largest percentage of the metal it contains at the least possible cost. Samples varying from 500 pounds to car-load lots can be treated by various methods.

As the funds appropriated for the erection of such a plant were sufficient to purchase only the necessary machinery, the business men of Minneapolis generously provided a suitable building. This building, 94 by 66 feet, is built of brick and stone.

Machinery.—The plant contains all the machinery necessary to illustrate the various processes of ore testing, viz., a Bridgman mechanical sampler, size B; a link belt bucket elevator; a pulley feeder complete; a pair of 12½ by 12 geared rolls complete; a four compartment spitzkasten; a three compartment Hartz jig; a Collum jig complete with cone for driving; a three and a half foot Huntington mill complete; a three-stamp mill, 275-pound stamps; a five-stamp mill, 850-pound stamps; a Challenge automatic feeder for five-stamp battery; a suspended Challenge feeder for three-stamp battery; a Tulloch feeder for Huntington mill; a single deck buddle, twelve feet in diameter; a four-foot plain belt Frue vanner; a Cammett concentrator; a Hooper pneumatic concentrator; a Century drop motion jig; a three-foot amalgamating pan; a five-foot settler; a Bruckner roasting furnace, with fire box on wheels; a chlorination barrel; a battery tightener; a two-horse-power vertical boiler; a steam drying pan; three trommels, with driving arrangement and gears; a one-thousand pound Reedy elevator, complete with worm gear; two overhead crawls, each with eighty-foot track; one-ton pulley block; a quarter-ton pulley block; a scoop car, with flat wheels; two twenty-horse-power electric motors; three MacDermott automatic samplers, etc.

FIELD WORK IN METALLURGY

At the end of the junior year opportunity is given the student to study metallurgical operations at one or more smelting works. This work will begin about May 1. Not over two weeks' time will be devoted to this work.

Upon termination of the junior field work in Metallurgy and two weeks in Mining (not later than June 1), the members of the junior class who are candidates for the degree of Metallurgical Engineer, are required to spend at least eight weeks in practical work in one or more of the smel-

ters of the West, for which he may receive wages. The department will render all possible assistance in locating students in the camps of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must, in person, submit this diary to the department on date of reopening of field work. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 9, 1913. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering field work in Metallurgy and Mining must be prepared at the School of Mines under the direct supervision of the departments concerned.

The program covering this work is as follows: Metallurgy, September 9-20, inclusive; Mining, September 22-30.

On September 29 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before September 29. These reports shall become the property of the School.

DEPARTMENTAL STATEMENTS

CHEMISTRY

George B. Frankforter, Ph.D., Professor	114 Chemistry Building
Charles F. Sidener, B.S., Professor	203 Chemistry Building
Francis C. Frary, Ph.D., Assistant Professor	108 Chemistry Building
Lillian Cohen, M.S., Instructor	106 Chemistry Building
Earl Pettijohn, M.S., Instructor	205 Chemistry Building
Woldemar M. Sternberg, B.S. Chem., Instructor	205 Chemistry Building
Sterling Temple, Ph.D., Instructor	207 Chemistry Building

1. General Chemistry — Miss Cohen

*Six credits (six hours per week); both semesters. Required of first-year students, five-year courses.

Recitation and laboratory work. The course includes a study of the common elements and their compounds, with an introduction to the modern theories of chemistry.

2. General and Qualitative Analysis

Professor Frankforter and Mr. Temple

Four credits (three lectures, two laboratory hours per week); first semester. Required of freshmen.

The course includes special general chemistry and the reactions of the metals as applied to their separation and identification.

3. Qualitative Analysis — Professor Frankforter and Mr. Temple

Four credits (one lecture, six laboratory hours per week); second semester. Open to students completing Course 2. Required of freshmen.

The work in this course will include examination of alloys, minerals, slags, and other compounds.

4. Quantitative Analysis

Professor Sidener, Messrs. Pettijohn and Sternberg

Four credits (one lecture, six laboratory hours per week); first semester. Open to students completing Course 3. Required of sophomores.

The course includes an introduction to quantitative, and a beginning of gravimetric analysis.

5. Volumetric Analysis

Professor Sidener, Messrs. Pettijohn and Sternberg

Four credits (one lecture, six laboratory hours per week); second semester. Open to students completing Course 4. Required of sophomores.

The course includes an introduction to volumetric determinations with a discussion of standard solutions and the necessary stoichiometric calculations.

*A credit is one recitation or lecture hour per week, per semester. Two laboratory hours are equal to one credit.

11a. Iron and Steel Analysis

Professor SIDENER, Messrs. PETTIJOHN and STERNBERG

Four credits (one lecture, six laboratory hours per week); second semester. Open to students completing Course 14. Required of seniors in E. M. and Met. E. Courses.

The course includes the rapid determination of iron by the various methods, as well as the determination of associated elements, sulphur, phosphorus, silicon, manganese, carbon, and others.

14. Special Problems

Professor SIDENER, Messrs. PETTIJOHN and STERNBERG

Four credits (one lecture, six laboratory hours per week); first semester. Open to students completing Course 4. Required of seniors in E. M. and Met. E. Courses.

The course includes the working out of various mineralogical, technological, and metallurgical problems, with work on ores of base metals, limestones, slags, etc.

22. Electro-Chemistry — Assistant Professor FRARY

Three credits (one lecture, four laboratory hours per week); second semester. Open to students completing Course 4. Required of seniors in Met. E. Course.

The course includes the qualitative and quantitative separation of metals by electrolysis.

DRAWING AND DESCRIPTIVE GEOMETRY

WILLIAM H. KIRCHNER, B.S., Professor — 208 Main Engineering Building
FRANK B. ROWLEY, B.S., M.E., Instructor — 207 Main Engineering Building
ROBERT W. FRENCH, B.S., Instructor — 211 Main Engineering Building
L. L. THURSTONE, M.E., Instructor — 111 Main Engineering Building

11. Engineering Drawing — Professor KIRCHNER and Mr. THURSTONE

Five credits (ten drafting hours per week); first semester. Required of freshmen in E. M. and Met. E. Courses, and of first-year students in E. M. (Geol.) Course.

Sketching, lettering, representation, parallel and radial projection, elements of engineering drawing, representation of details of machines and structures, interpretation of working drawings.

12. Engineering Drawing — Mr. THURSTONE

Four credits (eight drafting hours per week); second semester. Open to students completing Course 11. Required of freshmen in E. M. and Met. E. Courses, and of first-year students in E. M. (Geol.) Course.

Continuation of Course 11 as outlined above. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Maps and sketches. Brush and pen conventions.

13. Descriptive Geometry — Professor KIRCHNER

Two credits (two lectures per week); first semester. Open to students completing Course 12 and Mathematics 6. Required of sophomores.

Projection—central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems.

14. Drafting — Mr. French

Two credits (four drafting hours per week); second semester. Open to students completing Course 13. Required of sophomores.

Graphics, machine drafting, and structural drafting. Instruction in drafting room methods.

ELECTRICAL ENGINEERING

George D. Shepardson, M.A., M.E., Professor
30 Electrical Engineering Building
William T. Ryan, E.E., Assistant Professor
14 Electrical Engineering Building

4. Electric Power — Assistant Professor Ryan

Three credits (one lecture, four laboratory hours per week); first semester. Open to students completing Physics 3 and 4. Required of seniors in E. M. and Met. E. Courses.

Elements of theory and practice of electrical measurements, wiring, dynamos, motors, and electric lighting.

EXPERIMENTAL ENGINEERING

William H. Kavanaugh, M.E., Professor
107 Experimental Engineering Building
Charles F. Shoop, B.S., Assistant Professor
106 Experimental Engineering Building
Franklin R. McMillan, C.E., Instructor
106 Experimental Engineering Building

1. Strength of Materials — Mr. McMillan

Two credits (four laboratory hours per week); first semester. Open to students taking Mechanics 9. Required of juniors in E. M. and Met. E. Courses.

Laboratory work, investigating the strength and physical qualities of iron, steel, brass, copper, belting, chains, beams, brick, and stone.

2. Steam Laboratory — Assistant Professor Shoop

Two credits (four laboratory hours per week); second semester. Open to students completing Course 1. Required of juniors in E. M. and Met. E. Courses.

Exercises in valve setting, indicator practice, calibration of steam gauges, efficiency of screws and hoists.

5. Experimental Laboratory — Professor Kavanaugh

Two credits (four laboratory hours per week); second semester. Open to students completing Course 2. Required of seniors in E. M. and Met. E. Courses.

Hydraulic measurements. Calibration of weirs, nozzles, meters, and other hydraulic apparatus, calorimetry; tests of pumps, engines, and boilers.

FRENCH AND SPANISH

CHARLES W. BENTON, M. A., Litt.D., Professor of Romance Languages — 200 Folwell Hall
CHARLES M. ANDRIST, M.L., Professor — 228 Folwell Hall
JULES T. FRELIN, B.A., Assistant Professor — 228 Folwell Hall

FRENCH

1. Beginning — Professor ANDRIST and Assistant Professor FRELIN

Six credits (three hours per week); both semesters. Open to first-year students in E. M. (Geol.) Course.

French Grammar and Reader; modern texts.

2. Intermediate — Assistant Professor ANDRIST

Six credits (three hours per week); both semesters. Open to students completing Course 1.

Modern texts will be read, including some of the works of Coppée, Mérimée, Daudet, Scribe, etc.

3. Advanced Grammar and Composition — Assistant Professor ANDRIST

Six credits (three hours per week); both semesters. Open to students in E. M. (Geol.) Course who enter with two years of French.

Readings from modern authors, including selections from Coppée, Feuillet, and Sandeau.

5. The Classical Period of French Literature — Professor BENTON

Six credits (three hours per week); both semesters. Open to students completing Course 2 or 3.

The reading of works and selections produced during the classical period of French literature, and conversations in French concerning the same. The works of Corneille, Racine, Molière, La Fontaine, etc. Compositions.

SPANISH

11. Beginning — Assistant Professor FRELIN

Six credits (three hours per week); both semesters. Required of first-year students in E. M. and Met. E. Courses.

Monsanto and Languellier, *Spanish Course-Josselyn;* Worman, *First Spanish Book;* Bransby, *Spanish Reader.*

GEOLOGY AND MINERALOGY

WILLIAM H. EMMONS, Ph.D., Professor — 108 Pillsbury Hall
FRANK F. GROUT, M.S., Assistant Professor — 102 Pillsbury Hall
FREDERICK W. SARDESON, Ph.D., Assistant Professor — 103 Pillsbury Hall
OLIVER BOWLES, M.A., Instructor — 102 Pillsbury Hall
A. WALFRED JOHNSTON, M.A., Instructor — 112 Pillsbury Hall
EDGAR K. SOPER, M.A., Instructor — 112 Pillsbury Hall

1. General Mineralogy Assistant Professor GROUT and Mr. BOWLES

Six credits (four lectures, four laboratory hours per week); first semester. Required of freshmen.

The development of the systems of crystallization; the morphological, physical, and chemical characters of minerals; classification and description of common minerals; laboratory work, involving the application of chemical and blowpipe tests to the identification of species, with demonstrations; determination of minerals by physical properties, and sight identification. The occurrence, genesis, and use of minerals.

2. Physical Mineralogy Assistant Professor GROUT and Mr. BOWLES

Three credits (two lectures, two laboratory hours per week); second semester. Open to students completing Course 1. Required of freshmen.

A continuation of Course 1, special attention being given to economic and rock-forming minerals. Laboratory work, mineral determination and sight identification; introduction to the use of the goniometer and microscope. Reference reading and field excursions.

3. Elements of Geology Mr. SOPER

Three credits (three lectures per week); second semester. Required of sophomores.

The course is a synoptical treatment of the materials of the earth and of geologic processes; physiographic, structural, and dynamic geology, with a brief introduction to historical geology. Geologic structure is emphasized and the lectures are reinforced by the study of geologic maps.

3a. Field Work Mr. JOHNSTON and ASSISTANTS

One credit (first two weeks in June). Required of sophomores.

A two-week excursion to the Iron Ranges for practice in field methods, such as tracing contacts, working out structures, and constructing and interpreting geologic maps.

4. Historical and Economic Geology

Professor EMMONS and Mr. SOPER

Three credits (three lectures per week); first semester. Required of juniors.

(a) Historical Geology. The geologic history of North America, with special reference to its syngenetic mineral deposits.

(b) Economic Geology. A study of the occurrence, genesis, distribution, and uses of the non-metallic minerals of economic value, including a discussion of the geologic guides to prospecting for these deposits.

9. Elements of Rock Study

Assistant Professor GROUT and Mr. BOWLES

Two credits (four laboratory hours per week); second semester. Open to students completing Course 3. Required of sophomores.

The composition of the earth's crust, a general treatment of the origin, occurrence, and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and physical constitution; the alteration of rocks, the classification of igneous rocks; an introduction to the use of the microscope.

10. Petrology Assistant Professor GROUT and Mr. BOWLES

Two credits (four laboratory hours per week); second semester. Open to students completing Course 9. Required of juniors.

Laboratory work, lectures, and reference reading. The identification of minerals and rocks by optical study; a study of igneous rocks, followed by that of crystalline schists and metamorphic rocks; the origin and classification of rocks.

12. Ore Deposits — Professor EMMONS and Mr. SOPER

Four credits (four lectures per week); first semester. Open to students completing Course 10. Required of seniors.

A discussion of ore deposition; the nature, distribution, and genesis of metalliferous ore deposits of the United States. A study of the relation of ore deposits to geologic structure and of the changes which ore deposits undergo through oxidation and related processes. The course includes laboratory work illustrating the use of mine maps and geologic cross sections through mines, and detailed laboratory studies of reports on mining districts.

13. Special Problems in Ore Deposits — Professor EMMONS and Mr. SOPER

Two credits (four laboratory hours per week); second semester. Open to students completing Course 12. Required of seniors in E. M. and E. M. (Geol.) Courses.

Lectures on field and laboratory methods. A study of metallogenic epochs and metallographic provinces, particularly those of the United States.

13a. Seminar in Ore Deposits — Professor EMMONS

Three credits (three hours per week); second semester. Open to students completing Course 12. Required of seniors in E. M. (Geol.) Course.

Selected problems. Development of methods of research.

14. Introduction of Paleontology — Assistant Professor SARDESON

Three credits (three hours per week); first semester. Junior year.

Reading, lectures, and demonstrations. A study of the characters of leading types of fossils.

15. Paleontologic Practice — Assistant Professor SARDESON

Six credits (three lectures and six laboratory hours per week); second semester. Junior year.

Fossil collecting and preparation; identification and use of fossil species; index fossils and fauna-floras of the geologic series and formations.

GERMAN

JOHN G. MOORE, B.A., Professor of German — 210 Folwell Hall
OSCAR C. BURKHARD, M.A., Assistant Professor — 214 Folwell Hall
RICHARD WISCHKAEMPER, M.A., Instructor — 216 Folwell Hall

1. Beginning — Assistant Professor BURKHARD and Mr. WISCHKAEMPER

Six credits (three hours per week); both semesters. Open to first-year students in E. M. (Geol.) Course.

Pronunciation, grammar, conversation and composition; selected reading in easy prose and verse.

3. Scientific Intermediate — Assistant Professor BURKHARD and Mr. WISCHKAEMPER

Six credits (three hours per week); both semesters. Open to students completing Course 1.

This course is arranged to meet the peculiar needs of students of the School of Mines. Text: Merckel's *Bilder aus der Ingenieurtechnik*.

4. Prose and Poetry

Professor MOORE, Assistant Professor BURKHARD, and Mr. WISCHKAEMPER

Six credits (three hours per week); both semesters. Open to first-year students in E. M. (Geol.) Course who enter with two years of German.

Stern's *Aus deutschen Meisterwerken;* Goethe's *Gedichte;* Heine's *Buch der Lieder.* Geography, history, and legend. Review of German grammar throughout the year. This course may be supplemented.

7. Advanced Scientific Reading Assistant Professor BURKHARD

Six credits (three hours per week); both semesters. Open to students who have taken Course 3 or 4.

Reading of scientific monographs and periodicals.

MECHANICAL ENGINEERING

JOHN J. FLATHER, Ph.B., M.E., Professor — 105 Mechanical Engineering Building
S. CARL SHIPLEY, B.S., M.E., Assistant Professor — 100 Mechanical Engineering Building
WILLIAM H. RICHARDS, Instructor — 207 Mechanical Engineering Building
EDWARD QUIGLEY, Instructor — 111 Mechanical Engineering Building
PETER PETERSON, Instructor — 112 Mechanical Engineering Building

1. Carpentry Mr. RICHARDS

Four credits (six hours per week, nine weeks); second semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Wood working, use of tools; lathe and bench work. Patterns for moulding, core boxes, flasks. Lectures and practice.

2. Blacksmithing Assistant Professor SHIPLEY and Mr. QUIGLEY

Two credits (six hours per week, nine weeks); second semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Use of tools, forging, welding, tool dressing, tempering. Lectures and practice.

3. Foundry Practice Mr. PETERSON

Three credits (six hours per week, eighteen weeks); first semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Moulding, casting, mixing metals, brass work, and core making. Shop practice, recitations, and lectures.

MECHANICS AND MATHEMATICS

ELTING H. COMSTOCK, M.S., Professor — 4 Main Engineering Building
EDWIN M. LAMBERT, M.E., Assistant Professor — 4 Main Engineering Building
EDWARD W. DAVIS, B.S., Instructor — 4 Main Engineering Building

1. Algebra — Mr. Davis

Four credits (four recitations per week); first semester. Required of first-year students, five-year courses.

Review of Elementary Algebra, equations with one, two, or more unknown quantities, inequalities, involution and evolution, theory of exponents, surds, quadratic equations both numerical and literal, equations with one or more unknown quantities that can be solved by means of quadratic equations, progressions.

2. Solid Geometry and Mensuration — Mr. Davis

Three credits (three recitations per week); second semester. Required of first-year students, five-year courses.

Demonstrations of most important theorems, volumes, approximate volumes, prismoidal formula, etc.

3. Computation and Mensuration — Assistant Professor Lambert

Three credits (three recitations per week); first semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Approximate computation, graphs and graphical computation, logarithms and logarithmic computation, areas and approximations of areas.

4. Elementary Mine Accounting — Assistant Professor Lambert

Three credits (three lectures per week); second semester. Required of first-year students, five-year E. M. and Met. E. Courses.

Elementary accounting in general, applications to mine accounts; primary records, labor, supply, mine and mill products, and fund sheets; secondary records, invoice, labor and supply, mine and mill cost sheets, trial balance, etc.

5. Algebra and Trigonometry — Mr. Davis

Six credits (six recitations per week); first semester. Required of freshmen.

Functions and functional notation, factors and roots of general quadratics, factor and remainder theorems, factors and values of functions, determinants, development of functions and undetermined coefficients, derived functions, theory of equations, permutations and combinations; trigonometric ratios, right triangles, general definitions of trigonometric functions, analytic relations, addition formulas, etc.

6. Trigonometry and Analytic Geometry — Mr. Davis

Six credits (six recitations per week); second semester. Open to students completing Course 5. Required of freshmen.

Trigonometric equations, oblique triangles, spherical formulas and solution of spherical triangles; systems of co-ordinates, loci, straight line, transformations, equations of conics, properties of conics.

7. Analytic Geometry and Calculus — Assistant Professor Lambert

Five credits (five recitations per week); first semester. Open to students completing Course 6. Required of sophomores.

General equation of second degree, higher plane curves, co-ordinates in space, point, plane, straight line, quadric surfaces; nature of differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, elementary integration, expansion of functions, indeterminate forms, partial derivatives, change of variable.

8. Calculus — Assistant Professor Lambert

Three credits (three recitations per week); second semester. Open to students completing Course 7. Required of sophomores.

Applications continued, rational fractions, rationalization, formulas of reduction, multiple integration, various systems of co-ordinates, approximate integration, hyperbolic functions, some differential equations of mechanics; adjustments of observations.

9. Mechanics — Assistant Professor LAMBERT

Five credits (five recitations per week); first semester. Open to students completing Course 8, and Physics 3. Required of juniors.

Statics and dynamics, rectilinear, circular, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy; elementary mechanics of materials.

10. Mechanics — Assistant Professor LAMBERT

Six credits (six recitations per week); second semester. Open to students completing Course 9. Required of juniors.

Mechanical and elastic properties of materials of construction; beams, shafts, columns, reinforced concrete, hollow cylinders and spheres, rollers, plates; theory of internal stress.

11. Mine Plant — Professor COMSTOCK

Six credits (six lectures per week); first semester. Open to students taking Course 9. Required of juniors in E. M. and Met. E. Courses.

Discussion of the machinery and appurtenances employed in the equipment of mines. Hoisting, pumping, air compression, headframes, ore bins, etc.

13. Hydraulics and Water Power — Professor COMSTOCK

Five credits (five recitations and lectures per week); first semester. Open to students completing Course 10. Required of seniors.

Laws of the equilibrium, pressure, and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, number and type of units to install, speed control, power house equipment, transmission.

15. Engineering Construction

Professor COMSTOCK and Assistant Professor LAMBERT

Three credits (one lecture, four drafting hours per week); first semester. Open to students completing Course 10. Required of seniors in E. M. and Met. E. Courses.

Analytic and graphic resolution of stresses in framed structures, loads, stresses in mining structures, design of mining structures.

16. Mine Plant Design — Professor COMSTOCK

Three credits (six drafting hours per week); second semester. Open to students completing Course 15. Required of seniors in E. M. Course.

A study of power possibilities, costs, etc., and design of a power plant, surface equipment, and structures in connection with thesis work.

18. Mill and Smelter Design — Professor COMSTOCK

Three credits (six drafting hours per week); second semester. Open to students completing Course 15. Required of seniors in Met. E. Courses.

A study of the construction and mechanical equipment of mills and smelters in connection with thesis work.

METALLURGY

WILLIAM R. APPLEBY, M.A., Professor — 114 Main Engineering Building

PETER CHRISTIANSON, B.S., E.M., Professor — 5 Main Engineering Building

LEVI B. PEASE, M.S., Professor — 5 Main Engineering Building

SAMUEL L. HOYT, E.M., Assistant Professor
5 Main Engineering Building
EDMUND NEWTON, E.M., Instructor Ore Testing Works

1. Assaying Professor APPLEBY and ASSISTANTS

Eight credits (four lectures and eight laboratory hours per week); second semester. Open to students completing Mineralogy 1. Required of freshmen in E. M. and Met. E. Courses.

Determination of values of ores, metallurgical products and bullion.

2. General Metallurgy and Metallurgy of Iron
Professor CHRISTIANSON

Three credits (three lectures per week); first semester. Open to students completing Course 1. Required of sophomores in E. M. and Met. E. Courses.

Including the subjects of combustion, fuels, refractory materials, and furnaces. Lectures and recitations on metallurgy of iron.

3. Metallurgy of Wrought Iron and Steel Professor CHRISTIANSON

Three credits (three lectures per week); second semester. Open to students completing Course 2. Required of sophomores in E. M. and Met. E. Courses.

Consideration of the principles of manufacture, details of plant construction, and chemical and physical phenomena.

4. Metallurgy of the Base Metals Professor PEASE

Four credits (four lectures per week); first semester. Open to students completing Course 3. Required of juniors in E. M. and Met. E. Courses.

Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining methods.

5. Metallurgy of the Precious Metals Professor PEASE

Four credits (four lectures per week); second semester. Open to students completing Course 4. Required of juniors in E. M. and Met. E. Courses.

Gold, silver, and platinum. Methods and principles of cyanidation, chlorination, amalgamation, and lixiviation as applied to the treatment of the above.

6. Ore Testing Professor APPLEBY and ASSISTANTS

Six credits (two lectures and eight laboratory hours per week); first semester. Open to students completing Course 5 and Mining 7. Required of seniors in E. M. and Met. E. Courses.

Determination of methods of ore treatment, stamping, concentration, cyanidation, roasting, chlorination, lixiviation, and amalgamation.

7. Special Problems in Metallurgy Professor APPLEBY and ASSISTANTS

Four credits (eight laboratory hours per week); first semester. Open to students taking Course 6. Required of seniors in Met. E. Course.

Research work preparatory to thesis.

8. Electro-Metallurgy Professor CHRISTIANSON

Three credits (three lectures per week); first semester. Open to students completing Course 5. Required of seniors in Met. E. Courses.

A study of the reduction of ores, refining of metals and production of metals by electrolytic deposition; and the use of the electric furnace for smelting of ores, refining metals, and the manufacture of refractory alloys.

9. Metallography — Assistant Professor Hoyt

Four credits (two lectures, four laboratory hours per week); second semester. Open to students completing Course 3. Required of seniors in Met. E. Courses.

A study of the microstructure of metals and alloys as affected by heat and industrial treatments, together with the influence of changes of structure on their properties. Special attention is given to siderurgic products.

10. Field Work in Metallurgy — Professor Appleby and Assistants

Two credits (eight hours per day in field for seven days); June following second semester. Open to students completing Course 5. Required of juniors.

Study of metallurgical operations at smelters and mills. Detailed report is required covering plants visited.

11. Thesis and Specifications — Professors Appleby and Comstock

Five credits (ten hours, conference and laboratory); second semester. Open to students completing Course 9. Required of seniors in Met. E. Courses.

Detailed investigations of ore treatment, with report including designs and specifications for suitable plants.

MINING ENGINEERING

*Charles E. van Barneveld, B.A.Sc., E.M., Professor
3 Main Engineering Building

Edward P. McCarty, E.M., Professor
207 Main Engineering Building

Merton S. Kingston, E.M., Assistant Professor
207 Main Engineering Building

Ervin W. McCullough, E.M., Instructor
3 Main Engineering Building

1. Mine Surveying

Professor McCarty and Assistant Professor Kingston

Six credits (three lectures per week); both semesters. Open to students completing Mathematics 6. Required of sophomores.

Computation, platting, and problems with special reference to mine surveying.

2. Mining — Professor van Barneveld

One credit (one lecture per week); second semester. Required of sophomores.

Explosives and blasting.

3. Field Work — Professor van Barneveld and Assistants

Eight credits (eight hours per day for seven weeks); second semester. Open to students completing Course 1. Required of sophomores.

Practice in general surveying during month of May. Practice in underground surveying during first two weeks of June. This work is given on the Iron Ranges.

*On leave of absence 1913-16.

4. Mining — Professor VAN BARNEVELD

Five credits (five lectures per week); first semester. Open to students completing Course 2. Required of juniors.

Mode of occurrence of ore bodies; prospecting, drilling and blasting. Use of churn and diamond drill.

5. Mining — Professor VAN BARNEVELD

Five credits (five lectures per week); second semester. Open to students completing Course 4. Required of juniors.

Shaft-sinking, tunneling, drifting, stoping, timbering.

6. Mining — Professors VAN BARNEVELD and COMSTOCK

Three credits (three lectures per week); second semester. Open to students completing Course 4 and Mechanics 11. Required of juniors.

Hoisting, pumping, ventilation, underground transportation. Mining machinery. Electricity applied to mining.

7. Ore Dressing — Professor MCCARTY

Five credits (five lectures per week); second semester. Open to students completing sophomore work. Required of juniors.

Mechanical preparation of ore for the markets, for metallurgical treatment, etc.

8. Mine Mapping — Assistant Professor KINGSTON

Three credits (six drafting hours per week); second semester. Open to students completing Course 3. Required of juniors.

Mine mapping in accordance with prevalent practice in the western mining districts. Ore and stripping estimates and mine maps based on Mesabe Range practice.

9. Practical Mining — Professor VAN BARNEVELD and ASSISTANTS

Eight credits (eight hours per day for ten weeks); summer vacation. Open to students completing Course 6. Required of juniors.

Study of mining operations. Mine plant and equipment and practical mining work; a mine to be selected by department during months of May, June, July, and August.

10. Mining and Mining Engineering — Professor VAN BARNEVELD

Five credits (five lectures per week); first semester. Open to students completing Course 9. Required of seniors in E. M. Courses.

Methods of metal mining. Quarrying. Methods of coal mining. Hydraulic mining.

11. Mining and Mining Engineering — Professor VAN BARNEVELD

Five credits (five lectures per week); second semester. Open to students completing Course 10. Required of seniors in E. M. Courses.

Mine management, mine accounts, mining law, mining accidents, examination of a mining property, sampling ore reserves.

12. Designs and Specifications — Professor VAN BARNEVELD and COMSTOCK

Four credits (eight drafting hours per week); second semester. Open only to seniors in regular standing. Required of seniors in E. M. Courses.

Designs of mine cars, skips, head-frames, etc., in connection with thesis work.

13. Thesis

Professors VAN BARNEVELD and MCCARTY and Mr. MCCULLOUGH

Two and four credits (two and four-hour conferences); both semesters. Open only to seniors in regular standing. Required of seniors in E. M. Courses.

Conference with individual students. This work is based upon a review of the preceding technical work and field work.

PHYSICS

JOHN ZELENY, Ph.D., Professor — 15 Physics Building
JAMES COXE SANDERSON, Ph.D., Instructor — 32 Physics Building

1. General Physics — Professor JOHN ZELENY and Mr. SANDERSON

Three credits (three hours per week); first semester. Open to students completing Mathematics 6. Required of sophomores.

Mechanics of solids and fluids, heat and sound. This is the first part of an elementary course in Physics, designed for those who do not intend to pursue the subject longer than one year. The course is experimental rather than mathematical and gives the student a general knowledge of the fundamental principles of the subject. There will be one experimental lecture and two recitations each week.

2. General Laboratory Practice — Mr. SANDERSON

One credit (two hours per week); first semester. Open to students taking Course 1. Required of sophomores.

Physical measurements in the mechanics of solids and fluids, and in heat and sound, giving the student a knowledge of experimental methods.

3. General Physics — Professor JOHN ZELENY and Mr. SANDERSON

Three credits (three hours per week); second semester. Open to students completing Course 1. Required of sophomores.

Light, electricity, and magnetism. This is the second part of the elementary course begun under Course 1. The treatment is experimental and the fundamental principles of the subjects, including those of radioactivity, ionization, X radiation, and the electrical constitution of matter, are discussed and illustrated. There will be one experimental lecture and two recitations each week.

4. General Laboratory Practice — Mr. SANDERSON

One credit (two hours per week); second semester. Open to students taking Course 3. Required of sophomores.

Physical measurements in light, electricity, and magnetism, giving the student a knowledge of experimental methods.

RHETORIC

JOSEPH M. THOMAS, Ph.D., Professor — 310 Folwell Hall
WARREN T. POWELL, M.A., Instructor — 410 Folwell Hall

15. Rhetoric and Composition — Mr. POWELL

Eight credits (four hours per week); both semesters. Required of all freshmen.

This course is planned with special reference to the needs of engineering students. Practical training in writing will be given, and in connection with the written work the student will be required to study the work of those writers who have handled scientific subjects with clearness and power.

To broaden the scope of the student's knowledge and interests a course of outside reading will also be required.

STUDENTS

SENIORS—11

Coady, Leo. J., Minneapolis
Edwin, John, Minneapolis
Ely, Robert H., Duluth
Hammond, Arthur H., Minneapolis
Hanson, J. Bernard, Minneapolis
Hondrum, Olaf, Bemidji
Ladd, Greeley, Minneapolis
Michie, Roy G., Montevideo
Nissen, Arvid E., Minneapolis
Ofsthun, Norman H., Glenwood
Walker, Charles A., Brainerd

JUNIORS—7

Anderson, Arthur P., Minneapolis
Bierman, Alfred C., Litchfield
Eidemiller, Howard N., St. Paul
Larson, Ernest L., Akeley
Potter, Orrin W., St. Paul
Ravicz, Louis, Minneapolis
Robertson, John H., St. Paul

SOPHOMORES—19

Buresch, Charles E., Lakefield
Butler, W. Victor, Little Falls
Christenson, Alfred, Madelia
Clark, Malcolm W., Northfield
Coller, Walter A., St. Paul
Collins, Leon T., Pine Island
Dopp, J. Lawrence, Ashland, Wis.
Harmon, Sidney E., St. Paul
Haugan, Albert C., Hanska
Heilig, Louis S., Minneapolis
Johnson, Fred C., Willmar
Kerr, Charles D., St. Paul
Lee, Oscar, St. Paul
Neerland, Herman, Minneapolis
Nord, Harry H., Ashland, Wis.
Sanchez, Richard M., Tarma, Peru
Stene, James, Minneapolis
Urquhart, George K., St. Paul
Wade, Henry H., Hopkins

FRESHMEN—20

Abrahamson, Hjalmar, Wadena
Aronson, Sam, St. Paul
Capser, Leo W., St. Paul
Craig, John J., Minneapolis
Davies, Fred A., Minneapolis
Dovre, Adolph, Sleepy Eye
Ellis, George J., Minneapolis
Evleth, Everett B., St. Paul
Field, Reginald, Mobridge, S. D.
Fields, Austin, St. Paul
Hicks, John, Minneapolis
Johnson, Samuel A., St. Charles
Josephson, S. Sidney, Minneapolis
Krogh, Alvin T., Minneapolis
McDermid, Archibald J., Duluth
McHardy, Roy H., Minneapolis
Oglesby, Fred B., Valley City, N. D.
Ostrom, George E., Stillwater
Roll, George H., Ellsworth
Shapere, Abraham D., St. Paul

FIRST-YEAR CLASS—37

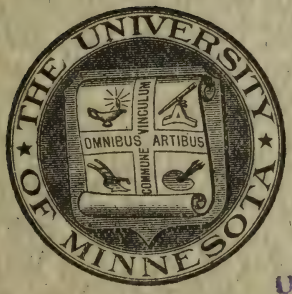
Anderson, Ray W., Cumberland, Wis.
Benton, George B., Minneapolis
Carter, Cuthbert, Minneapolis
Copeland, William A., St. Paul
Coryell, Lewis S., Osceola, Wis.
Cutler, Fred A., Jr., Minneapolis
Dunnell, Warren W., Minneapolis
Dwyer, T. Thomas R., Minneapolis
Elson, William H., St. Paul
Evleth, Earl M., St. Paul
Fearing, Edward J., Little Falls
Feeley, Chester B., Minneapolis
Frank, Harry, Minneapolis
Hall, Frank E., Little Falls
Jeffers, Roy L., Brainerd
Johnson, Harry W., Minneapolis
Kenkel, Herman H., St. Paul
Levorsen, A. Irving, Fergus Falls
McClure, Gilbert W., St. Paul
Marr, Ralph C., Minneapolis

Mattern, Joseph P., Minneapolis
Munson, Elmer E., Cokato
Murray, Floyd, Sparta
O'Gorman, James F., St. Paul
Oswald, Henry A., Minneapolis
Rafferty, Frank L., Wabasha
Reiter, Clarence J., Rochester
Shattuck, Warner A., Bisbee, Ariz.
Sinclair, Gilbert, Minneapolis
Solon, Lorin R., Minneapolis
Strand, Edwin L., Two Harbors
Strand, Harry W., Marine Mills
Sullivan, Daniel C., Stillwater
Tennesen, Edward, Minneapolis
Wallace, Carleton, Minneapolis
Wiggins, Porter, Minneapolis
Woodruff, John J., Minneapolis

The University of Minnesota

THE SCHOOL OF MINES

1914-1915



BULLETIN OF THE UNIVERSITY OF MINNESOTA
VOL. XVII, NO. 11. JUNE 1914

Entered at the Post-Office
in Minneapolis as second-class matter
Minneapolis, Minn.

The Bulletin of the University of Minnesota is issued as often as twice a month during the University year.

The Bulletin comprises—

Original Series. Containing the reports of the President and of the Board of Regents, the Register, the Bulletin of General Information, the annual announcements of the individual colleges of the University, etc.

General Series. Containing announcements of departments of instruction, reports of University officers, etc.

These publications will be sent gratuitously to all persons who apply for them. The applicant should state specifically which announcement or what information is desired. Address

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The University of Minnesota,
Minneapolis, Minnesota.

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The University of Minnesota

THE SCHOOL OF MINES

1914-1915

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1914

JULY

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NOVEMBER

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29	30	..	..	..	..	..
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DECEMBER

..	..	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	**19**
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27	**28**	**29**	**30**	**31**	..	..

1915

JANUARY

..	..	..	..	..	**1**	**2**
3	**4**	5	6	7	8	9
10	11	12	13	14	15	16
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24	25	26	27	28	29	30
31	..	..	..	..	..	..

FEBRUARY

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14	15	16	17	18	19	20
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MARCH

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APRIL

..	..	..	..	**1**	**2**	**3**
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MAY

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JUNE

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JULY

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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UNIVERSITY CALENDAR
1914-1915

The University year covers a period of thirty-eight weeks, beginning on the second Tuesday in September. Commencement Day is always the second Thursday in June.

1914

September	1	Tuesday	Registration closes except for new students
September	1-8	Week	Fees payable except for new students
September	7-15	Week	Supplementary entrance examinations, registration of new students, and payment of fees
September	9-15	Week	Military encampment of cadets
September	16	Wednesday	First semester begins
November	25	Wednesday	Thanksgiving recess begins 9:00 p.m.
November	30	Monday	Thanksgiving recess ends 8:00 a.m.
December	18	Friday	Christmas vacation begins 9:00 p.m.
1915			
January	5	Tuesday	Christmas vacation ends 8:00 a.m.
January	19	Tuesday	Registration for second semester closes
January	25	Monday	Final examinations begin
January	26	Tuesday	Payment of fees for second semester closes
February	3	Wednesday	Second semester begins
February	11	Thursday	First semester class reports due
February	12	Friday	Lincoln's Birthday: a holiday
February	22	Monday	Washington's Birthday: a holiday
March	31	Wednesday	Easter recess begins 9:00 p.m.
April	8	Thursday	Easter recess ends 8:00 a.m.
May	29	Saturday	Final examinations begin
June	5	Saturday	Second semester closes
June	6	Sunday	Baccalaureate service
June	7	Monday	Senior class day exercises
June	9	Wednesday	Alumni Day
June	10	Thursday	Forty-third Annual Commencement
June	11	Friday	Summer vacation begins
June	14	Monday	Summer Session begins

The University year for 1915-16 will begin Tuesday, September 7.

NOTE.—During the year 1913-14 there were 101 recitation days the first semester and 98 the second, inclusive of the final examination periods. In 1914-15 the number of recitation days will be exactly the same.

SCHOOL OF MINES

Program of Supplementary Examinations

Tuesday,	Sept. 8	9-12 a.m.	Mechanics and Mathematics
		2-5 p.m.	Mining Engineering Subjects
Wednesday,	Sept. 9	9-12 a.m.	Chemistry
		2-5 p.m.	Drawing and Descriptive Geometry
		2-5 p.m.	Mechanical Engineering Subjects
Thursday,	Sept. 10	9-12 a.m.	Metallurgical Subjects
		2-5 p.m.	Physics
Friday,	Sept. 11	9-12 a.m.	Electrical Engineering Subjects
		2-5 p.m.	Geology and Mineralogy

THE SCHOOL OF MINES

FACULTY

George Edgar Vincent, Ph.D., LL.D., President 1005 5th St. S. E.
Cyrus Northrop, LL.D., President, Emeritus 519 10th Ave. S. E.
William R. Appleby, M.A., Dean and Professor of Metallurgy 928 5th St. S. E.
Charles M. Andrist, M.L., Professor of French 706 Delaware St. S. E.
*Charles E. van Barneveld, B.A.Sc., E.M., Professor of Mining Engineering
Oscar C. Burkhard, M.A., Assistant Professor of German 719 E. River Road
Peter Christianson, B.S., E.M., Professor of Metallurgy 217 Union St. S. E.
Elting H. Comstock, M.S., Professor of Mechanics and Mathematics 1416 7th St. S. E.
William H. Emmons, Ph.D., Professor of Mineralogy and Geology 719 7th St. S. E.
Henry A. Erikson, Ph.D., Assistant Professor of Physics 424 Harvard St. S. E.
†John J. Flather, Ph.B., M.M.E., Professor of Mechanical Engineering 315 11th Ave. S. E.
George B. Frankforter, Ph.D., Professor of Chemistry 525 E. River Road
Francis C. Frary, Ph.D., Assistant Professor of Chemistry 305 Walnut St. S. E.
Jules T. Frelin, B.A., Assistant Professor of Romance Languages 112 Church St. S. E.
Frank F. Grout, M.S., Assistant Professor of Geology and Mineralogy 623 13th Ave. S. E.
Samuel L. Hoyt, E.M., Ph.D., Assistant Professor of Metallurgy 715 University Ave. S. E.
William H. Kavanaugh, M.E., Professor of Experimental Engineering 124 State St. S. E.
William H. Kirchner, B.S., Professor of Drawing and Descriptive Geometry 722 10th Ave. S. E.
Edwin M. Lambert, M.E., Assistant Professor of Mechanics and Mathematics 1086 12th Ave. S. E.
Edward P. McCarty, E.M., Professor of Mining 112 Church St. S. E.
Walter R. Myers, Ph.D., Assistant Professor of German
Everett W. Olmsted, Ph.D., Professor of Romance Languages
Levi B. Pease, M.S., Professor of Metallurgy 1070 16th Ave. S. E.

*On leave of absence 1913-16.
†On leave of absence 1914-15.

WILLIAM T. RYAN, E.E., Assistant Professor of Electrical Engineering 3228 4th St. S. E.
CARL SCHLENKER, B.A., Professor of German 514 11th Ave. S. E.
GEORGE D. SHEPARDSON, M.A., M.E., D.Sc., Professor of Electrical Engineering 717 E. River Road
S. CARL SHIPLEY, B.S., M. E., Assistant Professor of Machine Construction 1517 E. River Road
CHARLES F. SHOOP, B.S., Assistant Professor of Experimental Engineering 108 Beacon St. S. E.
CHARLES F. SIDENER, B.S., Professor of Chemistry 1320 5th St. S. E.
*JOSEPH M. THOMAS, Ph.D., Professor of Rhetoric 623 14th Ave. S. E.
GEORGE J. YOUNG, B.S., Professor of Mining Engineering 719 7th St. S. E.
ANTHONY ZELENY, Ph.D., Professor of Physics 613 Fulton St. S. E.
*JOHN ZELENY, Ph.D., Professor of Physics 712 10th Ave. S. E.

LILLIAN COHEN, Ph.D., Instructor in Chemistry 415 E. 14th St.
EDWARD W. DAVIS, B.S., Instructor in Mechanics and Mathematics 112 Church St. S. E.
ROBERT W. FRENCH, B.S., Instructor in Drawing 1018 16th Ave. S. E.
J. THEODORE GEISSENDOERFER, Ph.D., Instructor in German 967 14th Ave. S. E.
A. WALFRED JOHNSTON, M.A., Instructor in Geology 112 Church St. S. E.
PAUL E. KLOPSTEG, M.A., Instructor in Physics 1506 4th St. S. E.
ERVIN W. MCCULLOUGH, E.M., Instructor in Mining 3 Barton Ave. S. E.
FRANKLIN R. MCMILLAN, C.E., Instructor in Experimental Engineering 321 Oak St. S. E.
JOHN J. MURPHY, C.E., Instructor in Mining 617 University Ave. S. E.
EDMUND NEWTON, E.M., Instructor in Metallurgy 1034 14th Ave. S. E.
PETER E. PETERSON, Instructor in Foundry Practice 3709 Clinton Ave.
EARL PETTIJOHN, M.S., Instructor in Chemistry 2282 Carter Ave., St. Paul
EDWARD P. QUIGLEY, Instructor in Forge Work 2923 Chicago Ave.
WILLIAM H. RICHARDS, Instructor in Carpentry 1423 W. 27th St.
FRANK B. ROWLEY, B.S., M.E., Instructor in Drawing 217 Beacon St. S. E.
FRANK B. RUSSELL, M.A., Instructor in Rhetoric
JAMES C. SANDERSON, Ph.D., Instructor in Physics 1307 6th St. S. E.
E. H. SIRICH, Ph.D., Instructor in French
EDGAR K. SOPER, B.A., Instructor in Economic Geology 417 Union St. S. E.
WOLDEMAR M. STERNBERG, B.S.Chem., Instructor in Chemistry 3345 University Ave. S. E.
HERBERT K. STONE, M.A., Instructor in French
STERLING TEMPLE, M.A., Instructor in Chemistry 1758 Blair St., St. Paul
HOWARD T. VIETS, M.A., Instructor in Rhetoric
RICHARD WISCHKAEMPER, M.A., Instructor in German 504 Beacon St. S. E.

HOMER A. DESMARAIS, B.A., Assistant in French

*On leave of absence 1914-15.

SPECIAL INFORMATION

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M. (Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four or five years, and vice versa, provided such candidate completes an additional year's work at the School and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and the Mechanic Arts, and in the School of Analytical and Applied Chemistry, who contemplate taking a degree in this School after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thorough courses in Mechanics, Mathematics, Physics, and Chemistry.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine if it has value for treatment. (d) *Mining Engineering*—to furnish material for treatment. (e) *Ore Testing*—to determine best methods of treatment. (f) *Ore Dressing*—furnishing products for metallurgical treatment. (g) *Metallurgy*—smelting and refining ores and ore dressing products; reduction to metals.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

GRADUATION

Students completing courses of study to the satisfaction of the Faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the Faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations held at the end of the second semester. Irregular attendance will debar a student from entering all final examinations.

THESES

The thesis work is intended to bring in review and connect the work in Mining and Metallurgy, Geology and Mineralogy, Mechanical and Electrical Engineering, Mathematics and Mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of Field Work at the School of Mines, Tuesday, September 8, 1914, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the School.

SPECIAL NOTES

Students failing to receive a semester mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his yearly average in all subjects and present himself for supplementary examinations, according to the program given on page 4.

No other supplementary examination will be given. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to receive a semester mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The Faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

All students who voluntarily register for Military Drill shall be required to drill the entire year and be subject to the same rules and regulations as other cadets. Such students must receive credit or honorable dismissal from the department before graduating.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination at the end of the first or second semester will be given zero on the examinations.

Students whose absences in either semester exceed four weeks in the aggregate are not permitted to take examinations without special permission of the Faculty.

A fee of five dollars a subject is required for each special examination.

ADMISSION, REGISTRATION, FEES

For statements concerning requirements for admission, registration, and fees, consult Bulletin of General Information.

COURSES IN MINING ENGINEERING

COURSES LEADING TO THE DEGREE OF E.M.

FIRST YEAR—FIVE-YEAR COURSES

First Semester

Chemistry 1*, General, 6†
Mathematics 1, Algebra, 4
Mathematics 3, Computation and Mensuration, 3
Mechanical Engineering 4a, Foundry Practice, 6
Rhetoric 3, 3
Spanish 31, Beginning, 3

Second Semester

Chemistry 2, General, 6, Chem. 1
Mathematics 2, Solid Geometry and Mensuration, 3
Mathematics 4, Mine Accounting, 6
Mechanical Engineering 3a, Blacksmithing, 6 (9 weeks)
Mechanical Engineering 1a, Carpentry, 6 (9 weeks)
Rhetoric 4, 3, Rhet. 3
Spanish 32, Beginning, 3, Spanish 31

FRESHMAN YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 5, General and Analytical, 5
Drawing 11, Engineering Drawing, 10
Mathematics 5, Algebra and Trigonometry, 6, Math. 1, 2
Mineralogy 23, Elements of Mineralogy, 8

Second Semester

Chemistry 6, General and Analytical, 7, Chem. 5
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23

SOPHOMORE YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 101, Quantitative Analysis, 7, Chem. 5, 6
Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Mathematics 7, Calculus, 5, Math. 6
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6

*Odd numbers indicate first-semester courses; even numbers, second-semester courses. A combination of the two (e. g., 5 - 6) indicates courses continuing through the year. In the case of courses repeated the second semester, the suffix *a* indicates first semester; the suffix *b*, second semester.

†Figure following the descriptive name of a course indicates number of hours a week. Course names following indicate prerequisite courses.

Physics 3, General Laboratory Practice, 2, with Physics 1

Second Semester

Chemistry 102, Quantitative Analysis, 7, Chem. 101
Drawing 14, Drafting, 4, Draw. 13
Geology 1b, General Geology, 3, Mineral. 24
Geology 105b, Elements of Rock Study, 4, Mineral. 24
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Field Work. Months of May, June, July, and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geol. 1b, 105b, beginning about June 15
Underground Mining Work, beginning about July 1

JUNIOR YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Experimental Engineering 21, Steam Laboratory, 4, with Math. 11
Geology 73, Historical and Economic Geology, 3, Geol. 105b, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 6, Math. 8
Metallurgy 105, Base Metals, 4, Met. 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Math. 10
Geology 106, Petrology, 4, Geol. 105b
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 3, Mech. 11
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 10, 5, Min. 9
Mining 8, Ore Dressing, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 103, Iron and Steel Analysis, 7, Chem. 102
Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8

Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Chemistry 104, Ore and Slag Analysis, 7, Chem. 103
Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Mechanics 16, Mine Plant Design, 10, Mech. 15
Mining 12, 5, Min. 11
Mining 14, Thesis, 8, Min. 13

COURSES LEADING TO THE DEGREE OF E.M. (GEOLOGY)

FIRST YEAR

First Semester

Chemistry 1, General, 6
Drawing 11, Engineering Drawing, 10
French 1 or 3, 3, French 2 for 3
or
German 15 or 17, 3, German 16 for 17
Mathematics 1, Algebra, 4
Rhetoric 3, 3

Second Semester

Chemistry 2, General, 6
Drawing 12, Engineering Drawing, 8, Draw. 11
French 2 or 4, 3, French 1 or 3
or
German 16 or 18, 3, German 15 or 17
Mathematics 2, Solid Geometry and Mensuration, 3
Rhetoric 4, 3, Rhet. 3

FRESHMAN YEAR

First Semester

Chemistry 5, General and Analytical, 5
French 3 or 5, 3, French 2 or 4
or
German 17 or 23, 3, German 16 or 18
Mathematics 5, Algebra and Trigonometry, 6, Math. 1, 2
Mineralogy 23, Elements of Mineralogy, 8

Second Semester

Chemistry 6, General and Analytical, 7
French 4 or 6, 3, French 3 or 5
or
German 18 or 24, 3, German 17 or 23
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23

SOPHOMORE YEAR

First Semester

Chemistry 101, Quantitative Analysis, 7, Chem. 5, 6
Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Mathematics 7, Calculus, 5, Math. 6
Mineralogy (Advanced), 3
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1

Second Semester

Chemistry 102, Quantitative Analysis, 8, Chem. 5, 6
Drawing 14, Drafting, 4, Draw. 13
Geology 1b, General Geology, 3, Mineral. 24
Geology 105b, Elements of Rock Study, 4, Mineral. 24
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 8, 3, Met. 2
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Field Work. Months of May, June, July, and August
Mining 2f, Min. 2, Surveying, beginning about May 1
Geology 1f, Geol. 1b, 105b, beginning about June 15
Special Geological Field Work, beginning about July 1

JUNIOR YEAR

First Semester

Geology 73, Historical and Economic Geology, 3, Geol. 105b, 1b
Mechanics 9, 5, Math. 8
Mining 9, 5, Min. 6
Geology 11, Paleontology, 9, with Geol. 73
Electives, 10

Second Semester

Geology 106, Petrology, 4, Geol. 105b
Mechanics 10, 6, Mech. 9
Mining 10, 5, Min. 9
Mining 8, Ore Dressing, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Geology 124, Structural and Metamorphic, 3, Geol. 73, 105b
Electives, 5
Field Work. Months of May, June, July, and August
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1
Practical Geology 160, beginning about July 1

SENIOR YEAR

First Semester

Geology 111, Ore Deposits, 4, Geol. 106
Geology 247, Geology of Lake Superior District, 5, with Geol. 111
Elective, 5
Mechanics 13, Water Power, 5, Mech. 10
Mining 11, 5, Min. 10
Thesis, 10

Second Semester

Geology 112, Problems in Ore Deposits, 4, Geol. 111
Geology 214, Seminar in Ore Deposits, 3, Geol. 111
Geology 114, Geology of Western Mining Districts, 5, Geol. 111
Mining 12, 5, Min. 11
Electives, 5
Thesis, 10

DEPARTMENT OF MINING ENGINEERING

Mining Engineering extends through the sophomore, junior, and senior years. The subjects given, together with the sequence necessary, are treated in the accompanying outline of the course.

In the senior year, problems in hoisting, hauling, pumping, ventilation, and similar subjects become an important part of the work.

MINE SURVEYING

The work in surveying is given in the sophomore year and is designed solely for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi or Vermilion Range. The exact location will be announced in March of each year.

The students will be divided into squads of two to four. Each squad must provide itself with a 6-foot steel tape graduated to hundredths. The duration of the course will be seven weeks (5½ days of 8 hours each constitute a week). Each student will be required to complete satisfactorily the following exercises and surveys:

1. Chaining and taping
2. Compass work
3. Adjustment and use of wye and dumpy levels
4. Adjustment of mining transit
5. Reading angles
6. Traverse with transit and steel tape
7. Azimuth traverse with stadia
8. Determination of meridian, latitude, and time by solar and stellar observations

9. Survey of mining claim according to the regulations of the U. S. Government
10. Measurement of earthwork
11. Laying out railroad tangents, curves, and crossings
12. Exercises in plane table work and geological surveying
13. The survey of a mine

A full equipment of surveying instruments of the latest and best makes is furnished to each squad for this work.

This is followed by a course in Mine Mapping during the second semester of junior year.

Students who furnish satisfactory evidence of proficiency in this work may be given credit therefor. The department, however, reserves the right in any case to require such students to take a theoretical or a practical examination or both.

FIELD WORK IN MINING

Sophomore Year

After the close of the field work in Geology (last two weeks in June), members of the sophomore class are required to engage for six weeks in underground mining work on the Minnesota or Michigan iron ranges, for which they may receive wages.

Junior Year

Upon termination of the junior field work in Metallurgy (about May 15), the members of the junior class, who are candidates for the degree of Engineer of Mines, are required to devote two weeks to the study of mine plant and mine operation under the direction of the department. This work will be given in one of the leading western metal mining districts, exact location to be announced in April of each year. Thereafter, during the months of June, July, and August, the student is required to spend at least six weeks in actual underground mining work in the West, for which he may receive wages. The department will render all possible assistance in locating students in the camps of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must in person submit this diary to the department on the date of the reopening of field work. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 8, 1914. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering Field Work in Mining and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: Metallurgy, September 8-15, inclusive; Mining, September 16-28.

On September 28 all seniors who expect to graduate must register

for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before September 28. These reports shall become the property of the School.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reason, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

ORE DRESSING

The lectures and recitations in Ore Dressing extend through the second semester of the junior year, and comprise the detailed study of ore dressing and concentrating machinery, together with the study of typical combinations of dressing machines as found in the several mining districts of the United States. In connection with the theoretical work, the ore dressing and testing plant of the School is utilized for practical illustrations.

COURSES IN METALLURGY

COURSES LEADING TO THE DEGREE OF MET. E.

FIRST YEAR—FIVE-YEAR COURSES

First Semester

Chemistry 1, General, 6
Mathematics 1, Algebra, 4
Mathematics 3, Computation and Mensuration, 3
Mechanical Engineering 4a, Foundry Practice, 6
Rhetoric 3, 3
Spanish 31, Beginning, 3

Second Semester

Chemistry 2, General, 6, Chem. 1
Mathematics 2, Solid Geometry and Mensuration, 3
Mathematics 4, Mine Accounting, 6
Mechanical Engineering 3a, Blacksmithing, 6 (9 weeks)
Mechanical Engineering 1a, Carpentry, 6 (9 weeks)
Rhetoric 4, 3, Rhet. 3
Spanish 32, Beginning, 3, Spanish 31

FRESHMAN YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 5, General and Analytical, 5
Drawing 11, Engineering Drawing, 10
Mathematics 5, Algebra and Trigonometry, 6, Math. 1, 2
Mineralogy 23, Elements of Mineralogy, 8

Second Semester

Chemistry 6, General and Analytical, 7
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23

SOPHOMORE YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 101, Quantitative Analysis, 7, Chem. 5, 6
Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Mathematics 7, Calculus, 5, Math. 6
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, Laboratory Practice, 2, with Physics 1

Second Semester

Chemistry 102, Quantitative Analysis, 7, Chem. 101

Drawing 14, Drafting, 4, Draw. 13
Geology 1b, General Geology, 3, Mineral. 24
Geology 105b, Elements of Rock Study, 4, Mineral. 24
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Field Work. Months of May, June, July, and August
Mining 2f, Min. 2, Surveying, beginning about May 1
Geology 1f, Geol. 1b, 105b, beginning about June 15
Underground Mining Work, beginning about July 1

JUNIOR YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Experimental Engineering 21, Steam Laboratory, 4, with Math. 11
Geology 73, Historical and Economic Geology, 3, Geol. 105b, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 6, Math. 8
Metallurgy 105, Base Metals, 4, Met. 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Math. 10
Geology 106, Petrology, 4, Geol. 105b
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 3, Mech. 11
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 10, 5, Min. 9
Mining 8, Ore Dressing, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Smelter Work, beginning about June 1

SENIOR YEAR—FOUR- AND FIVE-YEAR COURSES

First Semester

Chemistry 103, Iron and Steel Analysis, 7, Chem. 102
Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Metallurgy 11, Special Problems, 8, Met. 106, Min. 8
Metallurgy 109, Electrometallurgy, 3, Met. 106

Second Semester

Chemistry 144, Electrochemistry, 5, Chem. 102

Chemistry 104, Ore and Slag Analysis, 7, Chem. 103
Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Mechanics 18, Mill and Smelter Design, 6, Mech. 15
Metallurgy 152, Metallography, 6, Met. 106
Metallurgy 12, Thesis, 10, Met. 11

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in Metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags are shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their reports in detail. This work is offered to students completing the necessary courses in Mineralogy and Chemistry.

ORE TESTING

The lectures treat of the use and purposes of all the machinery connected with the subject, supplemented by detailed drawings. There are complete testing works connected with the department where the student may see the working of, and handle for himself, crushers, rolls, Huntington mill, concentrating machinery, such as vanners, buddles, jigs, pan for amalgamation, settlers, reverberatory furnaces for oxidizing and oxidizing-chloridizing roasts, leaching and chlorination plants, as well as sizing apparatus and hydraulic separators. Sufficiently large amounts of ore are given to make the necessary tests upon the different machines and the students report the best method of treatment. The first semester of the senior year is devoted to instruction and laboratory work, and is required of students both in Mining and Metallurgy.

The ore-testing works meet educational, as well as commercial, needs.

Educational.—The ore-testing plant acquaints the student with the construction and manipulation of the principal typical machines used in the leading ore-dressing establishments of the country. It is here that students in Mining and Metallurgical Engineering get the requisite practical experience. They handle all machines and operate on sufficiently large amounts of material to determine the methods best suited to a given ore to extract the largest amount of metal with the least possible loss.

Commercial.—Ore-testing works are an important factor in mining and metallurgical projects. The commercial object is to determine the best method of treating a given ore so as to yield the largest percentage of the metal it contains at the least possible cost. Samples varying from 500 pounds to car-load lots can be treated by various methods.

As the funds appropriated for the erection of such a plant were sufficient to purchase only the necessary machinery, the business men of Minneapolis generously provided a suitable building. This building, 94 by 66 feet, is built of brick and stone.

Machinery.—The plant contains all the machinery necessary to illustrate the various processes of ore testing, viz., a Bridgman mechanical sampler, size B; a link belt bucket elevator; a pulley feeder complete; a pair of 12½ by 12 geared rolls complete; a four compartment spitzkasten; a three compartment Hartz jig; a Collum jig complete with cone for driving; a three and a half foot Huntington mill complete; a three-stamp mill, 275-pound stamps; a five-stamp mill, 850-pound stamps; a Challenge automatic feeder for five-stamp battery; a suspended Challenge feeder for three-stamp battery; a Tulloch feeder for Huntington mill; a single deck buddle, twelve feet in diameter; a four-foot plain belt Frue vanner; a Cammett concentrator; a Hooper pneumatic concentrator; a Century drop motion jig; a three-foot amalgamating pan; a five-foot settler; a Bruckner roasting furnace, with fire box on wheels; a chlorination barrel; a battery tightener; a two-horse-power vertical boiler; a steam drying pan; three trommels, with driving arrangement and gears; a one-thousand pound Reedy elevator, complete with worm gear; two overhead crawls, each with eighty-foot track; one-ton pulley block; a quarter-ton pulley block; a scoop car, with flat wheels; two twenty-horse-power electric motors; three MacDermott automatic samplers, etc.

FIELD WORK IN METALLURGY

At the end of the junior year opportunity is given the student to study metallurgical operations at one or more smelting works. This work will begin about May 1. Not over two weeks' time will be devoted to this work.

Upon termination of the junior field work in Metallurgy and two weeks in Mining (not later than June 1), the members of the junior class who are candidates for the degree of Metallurgical Engineer, are required to spend at least six weeks in practical work in one or more of the smelters of the West, for which he may receive wages. The department will render all possible assistance in locating students in the camps of their

choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must, in person, submit this diary to the department on date of reopening of field work. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 8, 1914. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering field work in Metallurgy and Mining must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: Metallurgy, September 8-15, inclusive; Mining, September 16-28.

On September 28 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before September 28. These reports shall become the property of the School.

METALLOGRAPHY

Courses in Metallography are offered to seniors who are candidates for the degree of Metallurgical Engineer, students in the Colleges of Science, Literature, and the Arts, Engineering, Chemistry, and the Graduate School.

These courses deal with the microscopic examination of metals, alloys, and ores. The lectures treat of and describe the apparatus used in connection with this subject, the methods of preparing specimens, the physical, chemical, and metallurgical principles involved, and the interpretation of the results of microscopic examination. A collection of specimens, microphotographs, and lantern slides covering wrought iron, low carbon, structural, rail, and tool steels, brasses, bronzes, and other industrial alloys are available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals, alloys, and ores. The laboratory is equipped with microscopes, electric and portable gas furnaces, and pyrometers of the latest and improved types. A special dark room is available for the preparation of microphotographs.

DEPARTMENTAL STATEMENTS

CHEMISTRY

Professors George B. Frankforter, Charles F. Sidener; Assistant Professor Francis C. Frary; Instructors Lillian Cohen, Earl Pettijohn, Woldemar M. Sternberg, Sterling Temple.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	General Chemistry	..	6	1st-yr. 5-yr. courses	..
2.	General Chemistry	..	6	1st-yr. 5-yr. courses	1
5.	Gen. & Anal. Chemistry	3	2	All Fr.	..
6.	Gen. & Anal. Chemistry	1	6	All Fr.	5
101.	Quantitative Analysis	1	6	All Soph.	6
102.	Quantitative Analysis	1	6	All Soph.	101
103.	Iron & Steel Analysis	1	6	Sr. E. M. & Met. E.	102
104.	Ore & Slag Analysis	1	6	Sr. E. M. & Met. E.	103
144.	Electrochemistry	1	4	Sr. Met. E.	102

1-2. General Chemistry. The course includes a study of the metallic and non-metallic elements, with a brief introduction to organic chemistry. Frankforter, Cohen, and Assistants.

5-6. General and Analytical Chemistry. An introduction to descriptive, physical, and metallurgical chemistry and qualitative analysis. Frankforter, Temple, and Assistants.

101-102. Quantitative Analysis. The course includes a general discussion of quantitative methods, with laboratory work in gravimetric analysis, first semester, followed by a discussion of standard solutions and the necessary stoichiometric calculations with laboratory work in volumetric analysis, second semester. Sidener, Pettijohn, Sternberg, and Assistants.

103. Iron and Steel Analysis. Includes technical methods for the determination of the common constituents of iron ores, iron, and steel, with training in rapid work. Sidener, Pettijohn, and Sternberg.

104. Ore and Slag Analysis. Rapid technical method for the determination of certain constituents in ores and slags. Sidener, Pettijohn, and Sternberg.

144. Electrochemistry. A discussion of electro-analytical methods and industrial electrochemical processes, and their underlying principles. Frary.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor William H. Kirchner; Instructors Robert W. French, Frank B. Rowley.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11.	Engineering Drawing	..	10	1st-yr. E. M. (Geol.) & Fr. E. M. & Met. E.	..

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
12.	Engineering Drawing	..	8	1st-yr. E. M. (Geol.) & Fr. E. M. & Met. E.	11
13.	Descriptive Geometry	2	..	All Soph.	12, Math. 6
14.	Drafting	..	4	All Soph.	13

11. Engineering Drawing. Sketching, lettering, representation, parallel and radial projection, elements of engineering, representation of details of machines and structures, interpretation of working drawings. Kirchner, French.

12. Engineering Drawing. Continuation of Course 11 as outlined above. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Maps and sketches. Brush and pen conventions. Rowley, French.

13. Descriptive Geometry. Projection: central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. Kirchner.

14. Drafting. Graphics, machine drafting, and structural drafting. Instruction in drafting room methods. French.

ELECTRICAL ENGINEERING.

Professor George D. Shepardson; Assistant Professor William T. Ryan.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
53.	Electric Power	1	4	Sr. E. M. & Met. E.	Physics 3, 4

53. Electric Power. Elements of theory and practice of electrical measurements, wiring, dynamos, motors, and electric lighting. Ryan.

EXPERIMENTAL ENGINEERING

Professor William H. Kavanaugh; Assistant Professor Charles F. Shoop; Instructor Franklin R. McMillan.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
21.	Steam Laboratory	..	4	Jr. E. M. & Met. E.	With Math. 11
22.	Strength of Materials	..	4	Jr. E. M. & Met. E	With Math. 10
24.	Experimental Laboratory	..	4	Sr. E. M. & Met. E.	21

21. Steam Laroratory. Exercises in valve setting, indicator practice, calibration of steam gauges, efficiency of screws and hoists. Shoop.

22. Strength of Materials. Laboratory work, investigating the strength and physical qualities of iron, steel, brass, copper, belting, chains, beams, brick, and stone. McMillan.

24. Experimental Laboratory. Hydraulic measurements. Calibration of weirs, nozzles, meters, and other hydraulic apparatus, calorimetry; tests of pumps, engines, and boilers. Kavanaugh.

GEOLOGY AND MINERALOGY

Professor William H. Emmons; Assistant Professor Frank F. Grout; Instructors A. Walfred Johnston, Edgar K. Soper.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1b.	General Geology	3	..	All Soph.	24
1f.	Field Work	..	2 wks.	All Soph.	1b & 105b
11.	Paleontology	3	6	Jr. E. M. (Geol.)	With 73
23.	Elements of Mineralogy	4	4	All Fr.	..
24.	Descriptive Mineralogy	2	2	All Fr.	23
73.	Histor. & Econ. Geology	3	..	All Jr.	1b & 105b
105b.	Elements of Rock Study	..	4	All Soph.	24
106.	Petrology	..	4	All Jr.	105b
111.	Ore Deposits	4	..	Sr. E. M. & E. M. (Geol.)	106
112.	Problems in Ore Deposits	..	4	Sr. E. M. & E. M. (Geol.)	111
114.	Geol. Western Mining Dists.	..	5	Sr. E. M. (Geol.)	111
115.	Advanced Petrology	..	4	Elective	111
124.	Struct. & Metamorph. Geol.	3	..	Jr. E. M. (Geol.)	73 & 105b
138.	Testing Econ. Minerals	..	4	Elective	24 & 73
144.	Construction & Interpretation of Geologic Maps	..	4	Elective	73
160.	Field Geology	..	6 wks	Jr. E. M. (Geol.)	106
214.	Seminar in Ore Deposits	3	..	Sr. E. M. (Geol.)	111
247.	Geol. & Exploration of Lake Superior Region	..	..	Sr. E. M. (Geol.)	With 111

1b. General Geology. A synoptical treatment of materials of the earth and of geologic processes. Physiographic, dynamic, and structural geology, with a brief introduction to Historical Geology. Johnston.

1f. Field Work. A two-week excursion to the Iron Ranges for practice in field methods, such as tracing contacts, working out structures and constructing and interpreting geologic maps. Johnston and Assistants.

11. Paleontology. Index fossils of North America. A study of fossils and fossilization. Uses of fossils in stratigraphic correlation.

23. Elements of Mineralogy. The crystal systems; morphological, physical, and chemical character of minerals; occurrence, genesis, and uses of minerals; classification and description of common minerals. Determinative work in laboratory, blowpipe analysis, sight identification. Grout.

24. Descriptive Mineralogy. A continuation of Course 23, special attention being given to metalliferous and rock-forming minerals. Laboratory determination and sight identification. The use of the goniometer and microscope. Laboratory work, reference reading, and field excursions. Grout.

73. Historical and Economic Geology. (a) Historical Geology. The geologic history of North America, with special references to its syngenetic mineral deposits. (b) Economic Geology. A study of the non-metallic minerals of economic value, and discussions of the geologic guides to prospecting for these deposits. Emmons, Soper.

105b. Elements of Rock Study. The occurrence and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. Grout.

106. Petrology. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and metamorphic rocks. The origin and classification of rocks. Grout.

111. Ore Deposits. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. Emmons, Soper.

112. Problems in Ore Deposits. Field excursions, map work, lectures on field and laboratory methods. Emmons, Soper.

114. Geology of Western Mining Districts. A study of the ore deposits of the West. A comparison of the more important deposits of the United States with foreign deposits. Emmons.

115. Advanced Petrology. The origin and alteration of rocks; their mineral and chemical composition; petrographic provinces, particularly those of the United States and Minnesota; advanced petrologic methods, microscopic, physical, and chemical. Grout.

124. Structural and Metamorphic Geology. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. Johnston.

138. Testing Economic Minerals. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, oil, building stone, and metallic ores.

144. Construction and Interpretation of Geologic Maps. Hours to be arranged. Methods of geological examination; problems in construction and interpretation of geologic maps and sections, with special reference to underground mapping of metalliferous areas; field practice in plane table methods of topographic and geologic mapping. Soper.

160. Field Geology. Six weeks in the field in the summer vacation period. Fields for 1914 are the Mesabi and Vermilion Ranges. Credit given only on completion of a satisfactory report. Johnston.

214. Seminar in Ore Deposits. Emmons.

247. Geology and Exploration of Lake Superior Region. The geology of the Lake Superior iron districts. The methods used in the exploration

of iron ores; interpretation of drill cores; cartographic expression of drill data; models of drilled areas. The principles of magnetic surveying. JOHNSTON.

GERMAN

Professor CARL SCHLENKER; Assistant Professors OSCAR C. BURKHARD, WALTER R. MYERS; Instructors J. THEODORE GEISSENDOERFER, RICHARD WISCHKAEMPER.

COURSES

No.	Title	Lect. or rec. hrs.	Required of	Prereq. courses
15.	Beginning German	3	1st-yr. E. M. (Geol.)	..
16.	Beginning German	3	1st-yr. E. M. (Geol.)	15
17.	Scientific Intermediate	3	1st-yr. or Fr. E. M. (Geol.)	16
18.	Scientific Intermediate	3	1st-yr. or Fr. E. M. (Geol.)	17
23.	Advanced Scientific	3	Fr. E. M. (Geol.)	18
24.	Advanced Scientific	3	Fr. E. M. (Geol.)	23

15-16. BEGINNING. Pronunciation, grammar, conversation, and composition; selected reading in easy prose and verse. BURKHARD.

17-18. SCIENTIFIC INTERMEDIATE. This course is arranged to meet the needs of students in the School of Mines. Text: Merckel's *Bilder aus der Ingenieurtechnik*. BURKHARD, MYERS.

23-24. ADVANCED SCIENTIFIC READING. Reading of monographs and periodicals. GEISSENDOERFER, WISCHKAEMPER.

MECHANICAL ENGINEERING

Professor JOHN J. FLATHER; Assistant Professor S. CARL SHIPLEY; Instructors PETER PETERSON, EDWARD QUIGLEY, WILLIAM H. RICHARDS.

COURSES

No.	Title	Lab. hrs.	Required of	Prereq. courses
1a.	Carpentry	6(9 wks.)	1st-yr. E. M. & Met. E.	..
3a.	Blacksmithing	6(9 wks.)	1st-yr. E. M. & Met. E.	..
4a.	Foundry	6	1st-yr. E. M. & Met. E.	..

1a. CARPENTRY. Woodworking, use of tools, bench work, wood-framing and timber joints. RICHARDS.

3a. BLACKSMITHING. Use of tools, forging, welding, tool-dressing, tempering. QUIGLEY.

4a. FOUNDRY PRACTICE. Moulding, casting, mixing metals, brass work, and core-making. PETERSON.

MECHANICS AND MATHEMATICS

Professor ELTING H. COMSTOCK; Assistant Professor EDWIN M. LAMBERT; Instructor EDWARD W. DAVIS.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Algebra	4	..	All 1st-yr. students	..
2.	Solid Geometry	3	..	All 1st-yr. students	..
3.	Computation & Mensuration	3	..	1st-yr. E. M. & Met. E.	..
4.	Mine Accounting	..	6	1st-yr. E. M. & Met. E.	..
5.	Algebra & Trigonometry	6	..	All Fr.	1 & 2
6.	Spherical Trig. & Anal. Geom.	6	..	All Fr.	5
7.	Calculus	5	..	All Soph.	6
8.	Calculus	3	..	All Soph.	7
9.	Mechanics	5	..	All Jr.	8
10.	Mechanics	6	..	All Jr.	9
11.	Mine Plant	6	..	Jr. E. M. & Met. E.	8
12.	Mine Plant	3	..	Jr. E. M. & Met. E.	11
13.	Hydraulics & Water-Power	5	..	All Sr.	10
15.	Engineering Construction	1	4	Sr. E. M. & Met. E.	10
16.	Mine Plant Design	..	10	Sr. E. M.	15
18.	Mill & Smelter Design	..	6	Sr. Met. E.	15

1. Algebra. Equations with one, two, or more unknown quantities, inequalities, involution and evolution, theory of exponents, surds, quadratic equations both numerical and literal, equations with one or more unknown quantities that can be solved by means of quadratic equations, progressions. Davis.

2. Solid Geometry and Mensuration. Demonstrations of most important theorems. Volumes, approximate volumes, prismoidal formula, etc. Davis.

3. Computation and Mensuration. Approximate computation, graphs, and graphical computation, logarithms and logarithmic computation, areas and approximations of areas, use of slide rule. Lambert.

4. Elementary Mine Accounting. Elementary accounting in general applications to mine accounts; primary records, labor, supply, mine and mill products, and fund sheets; secondary records, invoice, labor and supply, mine and mill cost sheets, trial balance. Lambert.

5. Algebra and Trigonometry. Functions and functional notation, factor and remainder theorems, factors and values of functions, determinants, development of functions, theory of equations, permutations and combinations; trigonometric ratios, right triangles, general definitions of trigonometric functions, analytic relations, addition formulas, trigonometric equations, and oblique triangles. Davis.

6. Spherical Trigonometry and Analytical Geometry. General properties and solution of spherical triangles; systems of coördinates, loci, equations and properties of the straight line, transformation of coördinates, equations and properties of conics, general equations of the second degree, higher plane curves, space coördinates, point, plane, straight line, quadric surfaces. Davis.

7. Calculus. Nature of differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, indeterminate forms, partial derivatives, change of variable. Lambert.

8. Calculus. Elementary integration, undetermined coefficients, rational fractions, rationalization, formulas of reduction, hyperbolic functions, some differential equations of mechanics. Lambert.

9. Mechanics. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy; elementary mechanics of materials. Lambert.

10. Mechanics. Mechanical and elastic properties of materials of construction; beams, shafts, columns, reinforced concrete, hollow cylinders and spheres, rollers, plates; theory of internal stress. Lambert.

11-12. Mine Plant. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. Comstock.

13. Hydraulics and Water-Power. Laws of the equilibrium, pressure, and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, speed control, power-house equipment, transmission. Comstock.

15. Engineering Construction. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures, design of mining structures. Comstock.

16. Mine Plant Design. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. Comstock.

18. Mill and Smelter Design. A study of the construction and mechanical equipment of mills and smelters in connection with thesis work. Comstock.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Assistant Professor Samuel L. Hoyt.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
2.	Assaying	4	8	All Fr.	Chem. 5, Mineral 23
3.	Gen. Met. & Iron and Steel	3	..	Soph. E. M. & Met. E.	2, Chem. 6
4.	Wrought Iron & Steel	3	..	Soph. E. M. & Met. E.	3
6f.	Field Work in Metallurgy	10 days		Jr. E. M. & Met. E.	Satisfactory completion of Jr. yr.
7.	Ore Testing	2	8	Sr. E. M. & Met. E.	106, Min. 8
8.	Metallurgy	3	..	Soph. E. M. (Geol.)	2
11.	Special Problems in Met	..	8	Sr. Met. E.	106, Min. 8
12.	Thesis & Specifications	..	10	Sr. Met. E.	11
105.	Met. of Base Metals	4	..	Jr. E. M. & Met. E.	4

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
106.	Met. of Precious Metals	4	..	Jr. E. M. & Met. E.	105
109.	Electrometallurgy	3	..	Sr. Met. E.	106
152.	Metallography	2	4	Sr. Met. E.	106
153.	Metallography	2	4	Elective	Chem. 104, Phys. 1 & 2
154.	Metallography	2	4	Elective	153
155.	Metallog. for Geologists	2	2	Elective	Geol. 73 & 106
156.	Metallog. for Geologists	2	2	Elective	155
158.	Metallog. for Engineers	3	..	Elective	Mech. Eng. 3 & 4
160.	Metallog. for Chemists	3	..	Elective	Chem. 104, Phys. 1 & 2

2. Assaying. Determination of values of ores, metallurgical products, and bullion. Appleby and Assistants.

3. General Metallurgy and Metallurgy of Iron. Including the subjects of combustion, fuels, refractory materials and furnaces. Lectures and recitations on metallurgy of iron. Christianson.

4. Metallurgy of Wrought Iron and Steel. Consideration of the principles of manufacture, details of plant construction, and chemical and physical phenomena. Christianson.

6f. Field Work in Metallurgy. Study of metallurgical operations at smelters and mills. Detailed report is required covering plants visited. Christianson, Pease.

7. Ore Testing. Determinations of methods of ore treatment, stamping, concentration, cyanidation, roasting, chlorination, lixiviation, and amalgamation. Appleby and Assistants.

8. Metallurgy. A short course covering the metallurgy of the principal metals. Christianson.

11. Special Problems in Metallurgy. Research work preparatory to thesis. Appleby and Assistants.

12. Thesis and Specifications. Detailed investigations of ore treatment, with report including designs and specifications for suitable plants. Appleby, Comstock, and Assistants.

105. Metallurgy of the Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining methods. Pease.

106. Metallurgy of the Precious Metals. Gold, silver, and platinum. Methods and principles of cyanidation, chlorination, amalgamation, and lixiviation as applied to the treatment of the above. Pease.

109. Electrometallurgy. A study of the reduction of ores, refining of metals, and production of metals by electrolytic deposition; and the use of the electric furnace for smelting of ores, refining metals, and the manufacture of refractory alloys. Christianson.

152. Metallography. A study of the microstructure of metals and alloys as affected by heat and industrial treatments, together with the influence of changes of structure on their properties. Special attention is given to siderurgic products. Hoyt.

153-154. Metallography. Study of constitution diagrams; the Phase Rule; microscopic and thermal analysis of alloys; relation between the constitution and physical and chemical phenomena of binary alloys; metallographic apparatus. Study of the commercial alloys, their heat and industrial treatments with special attention given to siderurgic products. Hoyt.

155-156. Metallography Applied to the Study of Geology. Application of metallographical principles and methods of research to geology, with special attention to the genesis of rocks and ore bodies. The microscopical examination of opaque minerals by reflected light. Hoyt.

158. Metallography for Engineering Students. Study of metallurgical principles, constitution of the steels and cast irons, influence of impurities. Metallographic study of foundry practice, heat and mechanical treatment of metals, influence of treatment and chemical composition on the physical properties of iron and steel. Microscopic examination of the commercial alloys. Preparation of specimens for microscopic examination, manipulation of the microscope, thermal analysis and heat treatment. Hoyt.

160. Metallography for Chemistry Students. Internal, physical, and chemical statics of metallic alloys, constitution diagrams, metallographic study of the iron-carbon alloys with particular attention to the chemical composition and microstructure. Principles of heat treatment and thermal analysis. Preparation of specimens for microscopical examination, and manipulation of the microscope. Hoyt.

MINING ENGINEERING

Professors George J. Young, Edward P. McCarty; Instructors Ervin W. McCullough, John F. Murphy.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Mine Surveying	3	..	All Soph.	Math. 6
2.	Mine Surveying	3	..	All Soph.	1
2f.	Field Work	..	7 wks.	All Soph.	2
4.	Mine Mapping	..	6	All Jr.	2f
6.	Mining	1	..	All Soph.	..
8.	Ore Dressing	5	..	All Jr.	9
9.	Mining	5	..	All Jr.	6
10.	Mining	5	..	All Jr.	9
10f.	Practical Mining	..	2 wks.	All Jr.	Satisfactory completion of Jr. yr.
11.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	10
12.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	11
13.	Thesis	..	2	Sr. E. M.	10f
14.	Thesis	..	8	Sr. E. M.	13

1, 2. Mine Surveying. Computation, platting, and problems with special reference to mine surveying. Murphy.

2f. Field Work. Practice in general surveying during the month of May. Practice in underground surveying during the first two weeks of June. This work is given on the Iron Ranges. McCarty, Murphy.

4. Mine Mapping. Mine mapping in accordance with prevalent practice in the western mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. Murphy.

6. Mining. Examination and testing, and use of explosives. McCullough.

8. Ore Dressing. Examination of ores, crushing, sizing classification, and methods of mechanical separation. Young.

9. Mining. Occurrence of ore bodies, prospecting, churn and diamond drilling, drilling, blasting, excavation, surface transportation, tunneling and drifting. Young.

10. Mining. Shaft-sinking, support of underground excavations, hoisting, drainage, ventilation, underground transportation. Young.

10f. Practical Mining. Study of mining operations. Mine plant and equipment and practical mining work; a mine to be selected by department during months of May, June, July, and August. Young, Comstock, and Assistants.

11. Mining. Open pit, quarrying, underground methods, coal mining, mining alluvial deposits. Young.

12. Mining. Mine management, mining law, economics of mining, mine examination, mine sanitation and hygiene. Young.

13, 14. Thesis. Conference. Design and specifications of mining details required in thesis study. Young.

PHYSICS

Professors John Zeleny, Anthony Zeleny; Assistant Professor Henry A. Erikson; Instructors Paul E. Klopsteg, James C. Sanderson.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	General Physics	3	..	All Soph.	Math. 6
2.	General Physics	3	..	All Soph.	1
3.	General Lab. Practice	..	2	All Soph.	With 1
4.	General Lab. Practice	..	2	All Soph.	With 2

1. General Physics. Mechanics of solids and fluids, sound and heat. Treatment experimental rather than mathematical; the fundamental principles. Zeleny, Sanderson, Klopsteg.

2. General Physics. Light, electricity, and magnetism. Treatment experimental; the fundamental principles, including those of radioactivity,

ionization, X-radiation, and the electrical constitution of matter. ZELENY, SANDERSON, KLOPSTEG.

3. GENERAL LABORATORY PRACTICE. Physical measurements in the mechanics of solids and fluids, and in heat and sound, giving the student a knowledge of experimental methods and an intimate acquaintance with the fundamental facts of the subject. ERIKSON, SANDERSON.

4. GENERAL LABORATORY PRACTICE. Physical measurements in light, electricity, and magnetism. ERIKSON, SANDERSON.

RHETORIC

Professor JOSEPH M. THOMAS; Instructors FRANK B. RUSSELL, HOWARD T. VIETS.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
3.	Composition (Engineers)	3	All 1st-yr. students	..
4.	Composition (Engineers)	3	All 1st-yr. students	3

3, 4. COMPOSITION FOR ENGINEERS. Practical training in writing with special reference to the needs of engineering students, and the study of those writers who have handled scientific subjects with clearness and power. A course of outside reading will also be required. RUSSELL, VIETS.

ROMANCE LANGUAGES

Professor EVERETT WARD OLMSTED; Assistant Professor JULES T. FRELIN; Instructors E. H. SIRICH, HERBERT K. STONE; Assistant HOMER DESMARAIS.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
1.	Beginning French	3	1st-yr. E. M. (Geol.)	..
2.	Beginning French	3	1st-yr. E. M. (Geol.)	1
3.	Intermediate French	3	1st-yr. or Fr. E. M. (Geol.)	2
4.	Intermediate French	3	1st-yr. or Fr. E. M. (Geol.)	3
5.	Survey French Lit	3	Fr. E. M. (Geol.)	4
6.	Survey French Lit	3	Fr. E. M. (Geol.)	5
31.	Beginning Spanish	3	1st-yr. E. M. & Met. E.	..
32.	Beginning Spanish	3	1st-yr. E. M. & Met. E.	31

1-2. BEGINNING FRENCH. Stress on accurate pronunciation, reading, reading vocabulary, and the essentials of grammar. Daily oral and written exercises (dictation and reproduction in French). DESMARAIS.

3-4. INTERMEDIATE. French grammar, composition, and reading; increased use of French in the classroom. Selections from modern prose and poetry. FRELIN, DESMARAIS.

5-6. GENERAL SURVEY OF FRENCH LITERATURE. Lectures, recitations, and assigned readings. Designed to cover the whole period in historical outline. Selections from representative authors. OLMSTED.

31-32. BEGINNING SPANISH. Pronunciation, grammar, conversation, and composition; selected reading in easy prose. OLMSTED.

Bulletin of The University of Minnesota

THE SCHOOL OF MINES

1915-1916

VOL. XVIII. NO. 11. JULY 1915

Entered at the Post-Office
in Minneapolis as second-class matter
Minneapolis, Minn.

1915

JULY

Su	Mo	Tu	W	Th	Fr	Sa
..	..	..	..	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
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25	26	27	28	29	30	31
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AUGUST

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SEPTEMBER

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NOVEMBER

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DECEMBER

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1916

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MAY

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JUNE

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JULY

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AUGUST

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OCTOBER

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NOVEMBER

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DECEMBER

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UNIVERSITY CALENDAR

1915-1916

The university year covers a period of thirty-eight weeks, beginning on the Tuesday before the second Thursday in September. Commencement Day is always the second Thursday in June.

1915			
August	31	Tuesday	Registration closes except for new students
September	1-8	Week	Fees payable except for new students
September	7-14	Week	Examinations for the removal of conditions (except Colleges of Agriculture and Forestry), entrance examinations, registration of new students, and payment of fees
September	15	Wednesday	First semester begins
September	27	Monday	Agricultural College, farm experience examination
October	4	Monday	School of Agriculture, first term begins
October	7	Thursday	Senate meeting, 4:00 p.m.
November	8	Monday	Dairy School opens
November	24	Wednesday	Thanksgiving recess begins 9:00 p.m.
November	29	Monday	Thanksgiving recess ends 8:00 a.m.
Nov. 29 to Dec. 4		Week	Second semester condition examinations, Colleges of Agriculture and Forestry
December	2	Thursday	Senate meeting, 4:00 p.m.
December	6-11	Week	Short course for ice-cream makers
December	11	Saturday	Dairy School closes
December	17	Friday	Christmas vacation begins 9:00 p.m.
December	17	Friday	School of Agriculture, first term closes
1916			
January	3-8	Week	Farmers' Short Course
January	4	Tuesday	Christmas vacation ends 8:00 a.m.
January	18	Tuesday	Registration for second semester closes
January	21	Friday	School of Agriculture, second term begins
January	24	Monday	Final examinations begin
January	25	Tuesday	Payment of fees for second semester closes
February	2	Wednesday	Second semester begins
February	3	Thursday	Senate meeting, 4:00 p.m.
February	12	Saturday	Lincoln's Birthday: a holiday
February	22	Tuesday	Washington's Birthday: a holiday
March	30	Wednesday	School of Agriculture closes

April	3-8	Week	Junior Short Course
April	19	Wednesday	Easter recess begins 9:00 p.m
April	27	Thursday	Easter recess ends 8:00 a.m.
May	1-6	Week	Condition examinations in certain colleges
May	2	Tuesday	Traction Engineering Course begins
May	4	Thursday	Senate meeting, 4:00 p.m.
May	26	Friday	Final examinations begin
May	30	Tuesday	Memorial Day: a holiday
June	1-8	Week	Military Encampment, Fort Snelling
June	3	Saturday	Second semester closes
June	4	Sunday	Baccalaureate service
June	5	Monday	Senior class day exercises
June	7	Wednesday	Alumni Day
June	8	Thursday	Forty-fourth Annual Commencement
June	9	Friday	Summer vacation begins
June	12	Monday	Summer Session begins

The university year for 1916-17 will begin Tuesday, September 12.

Program of Supplementary Examinations

Tuesday,	Sept. 7	9-12 a.m.	Mechanics and Mathematics
		2-5 p.m.	Mining Engineering Subjects
Wednesday,	Sept. 8	9-12 a.m.	Chemistry
		2-5 p.m.	Drawing and Descriptive Geometry
		2-5 p.m.	Mechanical Engineering Subjects
Thursday,	Sept. 9	9-12 a.m.	Metallurgical Subjects
		2-5 p.m.	Physics
Friday,	Sept. 10	9-12 a.m.	Electrical Engineering Subjects
		2-5 p.m.	Geology and Mineralogy

THE SCHOOL OF MINES

FACULTY

GEORGE EDGAR VINCENT, Ph.D., LL.D., President 1005 5th St. S. E.
CYRUS NORTHROP, LL.D., President Emeritus 519 10th Ave. S. E.
WILLIAM R. APPLEBY, M.A., Dean and Professor of Metallurgy 928 5th St. S. E.
*CHARLES E. VAN BARNEVELD, B.A.Sc., E.M., Professor of Mining Engineering
OSCAR C. BURKHARD, M.A., Assistant Professor of German 719 E. River Road
PETER CHRISTIANSON, B.S., E.M., Professor of Metallurgy 217 Union St. S. E.
ELTING H. COMSTOCK, M.S., Professor of Mine Plant and Mechanics 1416 7th St. S. E.
WILLIAM H. EMMONS, Ph.D., Professor of Mineralogy and Geology 611 11th Ave. S. E.
HENRY A. ERIKSON, Ph.D., Professor of Physics 424 Harvard St. S. E.
JOHN J. FLATHER, Ph.B., M.M.E., Professor of Mechanical Engineering 315 11th Ave. S. E.
GEORGE B. FRANKFORTER, Ph.D., Professor of Chemistry 525 E. River Road
FRANCIS C. FRARY, Ph.D., Assistant Professor of Chemistry 305 Walnut St. S. E.
JULES T. FRELIN, B.A., Assistant Professor of Romance Languages 1206 5th St. S. E.
FRANK F. GROUT, M.S., Assistant Professor of Geology and Mineralogy 617 4th St. S. E.
SAMUEL L. HOYT, E.M., Ph.D., Assistant Professor of Metallography 1011 14th Ave. S. E.
WILLIAM H. KAVANAUGH, M.E., Professor of Experimental Engineering 124 State S. E.
WILLIAM H. KIRCHNER, B.S., Professor of Drawing and Descriptive Geometry 722 10th Ave. S. E.
EDWIN M. LAMBERT, M.E., Assistant Professor of Mine Plant and Mechanics 1086 12th Ave. S. E.
EDWARD P. MCCARTY, E.M., Professor of Mining 3615 Lyndale Ave. S.
FRANKLIN R. MCMILLAN, C.E., Assistant Professor of Structural Engineering 524 8th Ave. S. E.
EVERETT W. OLMSTED, Ph.D., Professor of Romance Languages 901 5th St. S. E.
LEVI B. PEASE, M.S., Professor of Metallurgy 1070 16th Ave. S. E.
WILLIAM T. RYAN, E.E., Assistant Professor of Electrical Engineering 3228 4th St. S. E.

*On leave of absence 1913-16.

CARL SCHLENKER, B.A., Professor of German 514 11th Ave. S. E.
GEORGE D. SHEPARDSON, M.A., M.E., D.Sc., Professor of Electrical Engineering 717 E. River Road
S. CARL SHIPLEY, B.S., M.E., Assistant Professor of Machine Construction 1517 E. River Road
CHARLES F. SHOOP, B.S., Assistant Professor of Experimental Engineering 811 Fulton St. S. E.
CHARLES F. SIDENER, B.S., Professor of Chemistry 1320 5th St. S. E.
GEORGE J. YOUNG, B.S., Professor of Mining Engineering 719 7th St. S. E.
ANTHONY ZELENY, Ph.D., Professor of Physics 613 Fulton St. S. E.
EDWARD W. DAVIS, B.S., Instructor in Mechanics and Mathematics 979 14th Ave. S. E.
ROBERT W. FRENCH, B.S., Instructor in Drawing 1018 16th Ave. S. E.
J. THEODORE GEISSENDOERFER, Ph.D., Instructor in German 967 14th Ave. S. E.
A. WALFRED JOHNSTON, M.A., Instructor in Geology 112 Church St. S. E.
PAUL E. KLOPSTEG, M.A., Instructor in Physics 328 Oak St. S. E.
ERVIN W. MCCULLOUGH, E.M., Instructor in Mining 934 E. Bayliss Ave., St. Paul
JOHN J. MURPHY, C.E., Instructor in Mining 619 University Ave. S. E.
EDMUND NEWTON, E.M., Instructor in Metallurgy 941 14th Ave. S. E.
PETER E. PETERSON, Instructor in Foundry Practice 3709 Clinton Ave.
EARL PETTIJOHN, M.S., Instructor in Chemistry 2282 Carter Ave., St. Paul
EDWARD P. QUIGLEY, Instructor in Forge Work 2923 Chicago Ave.
WILLIAM H. RICHARDS, Instructor in Carpentry 1423 W. 27th St.
FRANK B. ROWLEY, B.S., M.E., Instructor in Drawing 217 Beacon St. S. E.
EDGAR K. SOPER, B.A., Instructor in Economic Geology 112 Church St. S. E.
WOLDEMAR M. STERNBERG, B.S.Chem., Instructor in Chemistry 3345 University Ave. S. E.
HERBERT K. STONE, M.A., Instructor in French 112 Church St. S. E.
STERLING TEMPLE, M.A., Instructor in Chemistry 1758 Blair St., St. Paul
RICHARD WISCHKAEMPER, M.A., Instructor in German 979 14th Ave. S. E.
HOMER A. DESMARAIS, B.A., Assistant in French 438 4th St. N. E.

GENERAL INFORMATION

The School of Mines was established by the Board of Regents in 1888, upon recommendation of the General Faculty of the University. The buildings and laboratories of the School are located on the main campus of the University. The mining districts of Minnesota are within a few hours, by rail, from Minneapolis. The heartiest coöperation exists between the various mine managements and the School, so that the mining properties are at all times open to parties from the school for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts. Students in the School of Mines have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

At the opening of the college year 1915-1916, the School of Mines will occupy the new building provided by the Legislature of 1913. In the basement are the assay and electro-metallurgical laboratories, together with machinery room, instrument room, balance room, furnace rooms, and necessary storerooms. On the first floor are the administrative offices, offices and lecture rooms of the departments of Metallurgy and Mine Plant and Mechanics. On the second floor are the offices, lecture rooms and drafting rooms of the department of Mining, the ore dressing laboratory, and the library of the school. On the third floor are the offices, laboratories, and lecture rooms of the department of Metallography, junior drafting room, photographic dark rooms, blue printing room, and offices and computing rooms for the branch of the Experiment Station serving the Tax Commission.

DEGREES

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M. (Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four or five years, and vice versa, provided such candidate completes an additional year's work at the School and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and the Mechanic Arts, and in the School of Analytical and Applied Chemistry, who contemplate taking a degree in this School after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thoro courses in mechanics, mathematics, surveying, physics, chemistry, and the necessary theory and practice of structural, mechanical and electrical engineering.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine if it has value for treatment. (d) *Mining Engineering*—to furnish material for treatment. (e) *Ore Testing*—to determine best methods of treatment. (f) *Ore Dressing*—furnishing products for metallurgical treatment. (g) *Metallurgy*—smelting and refining ores and ore dressing products; reduction to metals.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the state, to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the Tax Commission and to do such other work along the lines above outlined as may be requested by other state departments. Coöperation has been effected with the Minnesota Geological Survey and the School of Chemistry.

The Experiment Station is prepared to assist citizens interested in these lines of work; to assay specimens of ore, rocks, clays, and minerals found within the state free of charge.

In submitting samples the sender must state the exact location where each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the office of the Station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, The University of Minnesota, Minneapolis, Minnesota.

LIBRARY

The library occupies a well-lighted room, 55 feet by 61 feet, on the second floor of the School of Mines building. The books have been carefully selected and form a working collection of great value, not only to the faculty and students, but also the mining men of the state. Only books relating to mining, metallurgy, metallography, geology and allied subjects are shelved in this library, the general university library as well as the public libraries of Minneapolis and St. Paul serving as reserve collections. The library is especially rich in complete sets of periodicals, transactions, and the reports of state and foreign mining departments. Foreign technical literature is well represented. A card index is kept of all articles of value and interest appearing in the leading periodicals.

ADMISSION

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology) and Metallurgical Engineer may be completed in either four or five years. Students may enter the School of Mines without preparation in Higher Algebra and Solid Geometry. Such students must enter the five-year courses. It is recommended that students who come poorly prepared in Mathematics enter the five-year courses.

Students may be admitted to the School of Mines either by certificate or examination, or both.

ADMISSION BY EXAMINATION

Entrance examinations are offered at the University during the opening week, September 7 to 10. Candidates entering by this method must pass examinations in fifteen units so chosen as to satisfy the requirements outlined below. Certificates from the College Entrance Examination Board and from the High School Board are accepted in lieu of examinations in the subjects they represent. Those desiring to take examinations should notify the Registrar of the University in writing not later than August 31. See schedule of examinations, page 4.

ADMISSION BY CERTIFICATE

Graduates of the following courses, provided their preparation satisfies the requirements outlined below, may be admitted.

1. Any four-year course of a Minnesota state high school or other accredited school in the state.

2. A four-year course of schools in any other state accredited to the state university of that state.

3. The Advanced Latin and Advanced English courses of the Minnesota state normal schools.

The applicant for admission should request the principal or superintendent to forward to the Registrar of the University a complete transcript of his high-school or preparatory-school record showing the num-

ber of weeks and hours per week spent upon each study, with the grades entered as *passed, passed with credit,* or *passed with honor.* Credential blanks prepared by the University must be used; these blanks may be secured upon application to the Registrar. Upon receipt of the credentials at the University the Registrar will notify the applicant with regard to his admission.

ENTRANCE REQUIREMENTS

FIVE-YEAR COURSES

English, three units; Elementary Algebra and Plane Geometry, one unit each; ten additional units, of which not more than four may be in Group F.

FOUR-YEAR COURSES

Same as five-year courses with the addition of one-half unit each of Higher Algebra and Solid Geometry. It is recommended that students who enter these courses review Higher Algebra and Solid Geometry. Those unable to carry freshman mathematics satisfactorily will be required to drop back into the five-year course.

LIST OF ENTRANCE SUBJECTS

The term *unit* means not less than five recitations of forty minutes each per week for a period of thirty-six weeks. In manual subjects and kindred courses, it means the equivalent of ten recitation periods per week for thirty-six weeks.

Group A. English, three units.

Group B. Languages: Latin, Greek, German, French, Spanish, Scandinavian, one to four units each.

Group C. History and Social Sciences: Ancient and Modern History, one unit each; English and Senior American History, one-half unit each; American Government, Economics, Economic History of England, and Economic History of the United States, one-half unit each; Commercial Geography, and History of Commerce, one-half or one unit each.

Group D. Mathematics. Elementary Algebra and Plane Geometry, one unit each; Higher Algebra, Solid Geometry, and Trigonometry, one-half unit each.

Group E. Natural Sciences. Physics and Chemistry, one unit each; Botany and Zoology, one-half or one unit each; Physiology, Astronomy, Geology, and Physiography, one-half unit each.

Group F. Vocational Subjects: Business Law and Business Arithmetic, one-half unit each; Elementary and Advanced Bookkeeping, one unit each; Stenography and Typewriting, one or two units. Freehand Drawing, Mechanical Drawing, and Shopwork, one or two units each. Agriculture, one to four units. Normal Training subjects, one to three units, provided the applicant has had one year of subsequent teaching experience.

DESCRIPTION OF SUBJECTS ACCEPTED FOR ADMISSION

A description of the subjects accepted for admission to the University will be found in the Bulletin of General Information, which will be sent to any address upon application to the Registrar, The University of Minnesota, Minneapolis, Minnesota.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

ADMISSION TO ADVANCED STANDING

This University accepts records from all reputable colleges and universities for credit to advanced standing. Such records are accepted as far as they are equivalent to the work done in this institution. In bringing records from other institutions, the certificate must be upon the official blank of the institution granting the certificate and should show:

(a) The subject studied; if a language, the books, read, etc.
(b) The number of weeks and hours per week spent upon each subject.
(c) Ground covered in laboratory work in case of laboratory subjects.
(d) The result. The exact grades should be stated, accompanied by an explanation of the marking system employed.

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee of the School of Mines.

EXPENSES

One half of the Annual Incidental Fee of $55.00, which includes all laboratory charges, is payable at the opening of each semester. Cards entitling the student to admission to classes will not be issued until the fees have been paid. Books and supplies for each year of the course cost approximately $25.00. Field-work expense during the sophomore year is estimated at $150.00 and for the junior year at $225.00.

DEPOSIT FEE

At the beginning of each year, in addition to the first semester incidental fee, a deposit fee of five dollars is required of every student to cover the following items:

Change of Registration..... $2.50
Examination for removal of condition at set time....$1.00 per subject
Rental of post-office box, University post-office (required of all) ..... .50 per year
Locker rental, locker key deposit.....$.50 to $1.00 per year
Laboratory breakages, or damage to University property.
Penalties for late registration or late payment of fees.

A penalty fee of one dollar ($1.00) must be paid by all students who register or pay fees after the prescribed time. (See calendar,

page 3.) After the day previous to that on which classes begin, the penalty for delay increases at the rate of twenty-five cents a day.

The unused balance of the deposit fee will be returned at the end of each year. If, at any time during the college year, the amount of charges against a student exceed the amount of the deposit, a second fee of five dollars ($5.00) will be required.

SPECIAL FEES

The following special items may be included in the expenses of a student:

Minnesota Union membership.....$1.00 per semester
Special examination for removal of condition, at other than the set time 5.00
Examination on subject taken out of class..... 5.00
No fee for such examinations on first entering the University, if taken within the first six weeks.
Military uniform 15.00
Gymnasium suit 5.00

THE ELLIOT SCHOLARSHIP LOAN FUND

To fulfill the wish of the late Dr. A. F. Elliot to aid young men who find their efforts to obtain a practical education embarrassed through lack of means, the sum of $5,000 was placed in the hands of the Board of Regents as a scholarship fund. The income from this fund is loaned students in the School of Mines on the following conditions: the financial needs of the applicant, his scholarship, moral character, enthusiasm shown in his work, and promise of usefulness in his profession. When money is available, it may be loaned to pay the expenses of worthy students during sickness. The loans are to be repaid, without interest, at the earliest convenience of the recipients.

GRADUATION

Students completing courses of study to the satisfaction of the Faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the Faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations held at the end of the second semester. Irregular attendance will debar a student from entering all final examinations.

THESIS

The thesis work is intended to bring in review and connect the work in Mining and Metallurgy, Geology and Mineralogy, Mechanical and Electrical Engineering, Mathematics and Mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of Field Work at the School of Mines, Tuesday, September 7, 1915, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the School.

SPECIAL NOTES

Students failing to receive a semester mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his average in all subjects and present himself for supplementary examinations, according to the program given on page 4.

Failure of the Registrar to notify a student of deficiencies will not be accepted as a reason for neglecting to report for necessary supplementary examinations. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining

and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

Students failing to receive a semester mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The Faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination at the end of the first or second semester will be given zero on the examinations.

Students whose absences in either semester exceed four weeks in the aggregate are not permitted to take examinations without special permission of the Faculty.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

During the academic year students will be held responsible for the receipt of official communications sent to them through the University post-office. During the summer vacation they will be held responsible for the receipt of such communications sent to their home address as given on their registration blank for the preceeding academic year, unless formal notification of their correct address is filed with the Registrar and the Dean.

COURSES OF STUDY

UNIFORM CURRICULUM TO END OF SOPHOMORE YEAR

The courses leading to the degrees of Engineer of Mines, Engineer of Mines in Geology, and Metallurgical Engineer, are uniform for the first three years of the five-year courses and for the first two years of the four-year courses.

FIVE--YEAR COURSES

FIRST YEAR

First Semester

Chemistry 5*, General and Analytical, 5†
Mathematics 1, Computation and Mensuration, 4
Mathematics 3, Mine Accounting, 6
Mechanical Engineering 1, Shop Work, 6
Mineralogy 23, Elements of Mineralogy, 8
Military Drill

Second Semester

Chemistry 6, General and Analytical, 7, Chem. 5
Mathematics 2, Algebra, 4
Mechanical Engineering 1, Shop Work, 6
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23
Military Drill

FRESHMAN YEAR

First Semester

Chemistry 11, Quantitative Analysis, 7, Chem. 5, 6
Drawing 11, Engineering Drawing, 10
Geology 105, Elements of Rock Study, 4, Mineral. 24
Mathematics 5, Algebra and Trigonometry, 6, Math. 1, 2
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Military Drill

*Odd numbers indicate first-semester courses; even numbers, second-semester courses. A combination of the two (e. g., 5-6) indicates courses continuing through the year. In the case of courses repeated the second semester, the suffix *a* indicates first semester; the suffix *b*, second semester.

†Figure following the descriptive name of a course indicates number of hours a week. Course names following indicate prerequisite courses.

Second Semester

Chemistry 12, Quantitative Analysis, 7, Chem. 11
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Geology 1b, General Geology, 3, Mineral, 24
Geology 106, Petrology, 4, Geol. 105
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Military Drill

SOPHOMORE YEAR

First Semester

Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Mathematics 7, Calculus, 5, Math. 6
Geology 73, Historical and Economic Geology, 3, Geol. 106
Metallurgy 105, Base Metals, 4, Met. 4
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1

Second Semester

Drawing 14, Drafting, 4, Draw. 13
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 2, Mine Surveying, 3, Min. 1
Mining, 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Field Work. Months of May, June, July and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geol. 1b, 105, beginning about June 15
Underground Mining Work, beginning about July 1

FOUR-YEAR COURSES

FRESHMAN YEAR

First Semester

Chemistry, 5 General and Analytical, 5
Drawing 11, Engineering Drawing, 10
Mathematics 5, Algebra and Trigonometry, 6
Mineralogy 23, Elements of Mineralogy, 8
Military Drill

Second Semester

Chemistry 6, General and Analytical, 7, Chem. 5
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5

Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23
Military Drill

SOPHOMORE YEAR

First Semester

Chemistry 11, Quantitative Analysis, 7, Chem. 5, 6
Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Geology 105, Elements of Rock Study, 4, Mineral. 24
Mathematics 7, Calculus, 5, Math. 6
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1
Military Drill

Second Semester

Chemistry 12, Quantitative Analysis, 7, Chem. 101
Drawing 14, Drafting, 4, Draw. 13
Geology 1b, General Geology, 3, Mineral. 24
Geology 106, Elements of Rock Study, 4, Mineral. 24
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Military Drill
Field Work. Months of May, June, July, and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geo. 1b, 105, beginning about June 15
Underground Mining Work, beginning about July 1

COURSES IN MINING ENGINEERING

COURSES LEADING TO THE DEGREE OF E.M.

FIVE-YEAR COURSES

JUNIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 3, Math. 8
Mining 7, Ore Dressing, 5, Geol. 106
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Geology 112, Problems in Ore Deposits, 4 Geol. 111
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering 53, Electric Power, 5, Physics, 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8.
Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Mechanics 16, Mine Plant Design, 10, Mech. 15
Metallurgy 12, Special Problems, 4, Met. 7
Mining 12, 5, Min. 11
Mining 14, Thesis 12, Min. 13

FOUR-YEAR COURSES

JUNIOR YEAR

First Semester

Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 73, Historical and Economic Geology, 3, Geol. 106, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 3, Math. 8
Metallurgy 105, Base Metals, 4, Met. 4
Mining 7, Ore Dressing, 5, Geol. 106
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Metallurgy 12, Special Problems, 4, Met. 7
Mechanics 16, Mine Plant Design, 10, Mech. 15
Mining 12, 5, Min. 11
Mining 14, Thesis, 12, Min. 13

COURSES LEADING TO THE DEGREE OF E.M. (GEOLOGY)

JUNIOR YEAR

First Semester

Geology 73, Historical & Economic Geology 3, 106, 1b
Geology 57, Paleontology 3, 1b
German 15 or 17, 3, German 16 for 17
or
French 1 or 3, 3, French 2 for 3
Metallurgy 155, Metallography 4
Mining 9, 5, Min. 6
Elective 6 to 10

Second Semester

Geology 124, Structural and Metamorphic Geology 3, 73
Geology 58, Paleontology 3, 57
German 16 or 18, 3 German 15 or 17
or
French 2 or 4, 3, French 1 or 3
Metallurgy 156, Metallography 4, 155
Mining 10, 5, Min. 9
Mining 4, Mine Mapping 6, Min. 2f
Elective 3
Field work to be arranged

SENIOR YEAR

First Semester

Geology 111, Ore Deposits 4, 73
Geology 151, Advanced General Geology, 3
Geology 113, Laboratory course in Economic Geology, 4, with 111
German 17 or 23, 3, German 16 or 18
or
French 3 or 5, 3, French 2 or 4
Mining 11, 5, Min. 10
Thesis, 2
Elective 3

Second Semester

Geology 112, Problems in Ore Deposits 4, Geol. 111
Geology 152, Advanced General Geology, 3
Geology 144, Construction and Interpretation of Geologic Maps, 3, Geol. 111
Geology 138, Testing of Economic Minerals, 3
German 18 or 24, 3, German 17 or 23
or
French 4 or 6, 3, French 3 or 5
Mining 12, 5, Min. 11
Thesis, 4

DEPARTMENT OF MINING ENGINEERING

Mining Engineering extends through the sophomore, junior, and senior years. The subjects given, together with the sequence necessary, are treated in the accompanying outline of the course.

In the senior year, problems in hoisting, hauling, pumping, ventilation, and similar subjects become an important part of the work.

MINE SURVEYING

The work in surveying is given in the sophomore year and is designed solely for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi or Vermilion Range. The exact location will be announced in March of each year.

The students will be divided into squads of two to four. Each squad must provide itself with a 6-foot steel tape graduated to hundredths. The duration of the course will be seven weeks (5½ days of 8 hours each constitute a week). Each student will be required to complete satisfactorily the following exercises and surveys:

1. Chaining and taping
2. Compass work
3. Adjustment and use of wye and dumpy levels
4. Adjustment of mining transit
5. Reading angles
6. Traverse with transit and steel tape
7. Azimuth traverse with stadia.
8. Determination of meridian, latitude, and time by solar and stellar observations
9. Survey of mining claim according to the regulations of the U. S. Government
10. Measurement of earthwork.
11. Laying out railroad tangents, curves, and crossings
12. Exercises in plane table work and geological surveying
13. The survey of a mine

A full equipment of surveying instruments of the latest and best makes is furnished to each squad for this work.

This is followed by a course in Mine Mapping during the second semester of junior year.

Students who furnish satisfactory evidence of proficiency in this work may be given credit therefor. The department, however, reserves the right in any case to require such students to take a theoretical or a practical examination or both.

FIELD WORK IN MINING

Sophomore Year

After the close of the field work in Geology (last two weeks in June), members of the sophomore class are required to engage for six weeks in underground mining work on the Minnesota or Michigan iron ranges, for which they may receive wages.

Junior Year

Upon termination of the junior field work in Metallurgy (about May 15), the members of the junior class, who are candidates for the degree of Engineer of Mines, are required to devote two weeks to the study of mine plant and mine operation under the direction of the department. This work will be given in one of the leading western metal mining districts, exact location to be announced in April of each year. Thereafter, during the months of June, July, and August, the student is required to spend at least six weeks in actual undeground mining work in the West, for which he may receive wages. The department will render all possible assistance in locating students in the camps of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must in person submit this diary to the department on the date of the reopening of field work. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 7, 1915. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering Field Work in Mining and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: Metallurgy, September 7-14, inclusive; Mining, September 15-27.

On September 27 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before September 27. These reports shall become the property of the School.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reason, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

ORE DRESSING

The lectures and recitations in Ore Dressing extend through the second semester of the junior year, and comprise the detailed study of ore dressing and concentrating machinery, together with the study of typical combinations of dressing machines as found in the several mining districts of the United States. In connection with the theoretical work, the ore dressing and testing plant of the School is utilized for practical illusrations.

COURSES IN METALLURGY

COURSES LEADING TO THE DEGREE OF MET. E.

FIVE-YEAR COURSES

JUNIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 3, Math. 8
Mining 7, Ore Dressing, 5, Geol. 106
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Metallurgy 11, Special Problems, 8, Met. 106, Min. 8
Metallurgy 109, Electrometallurgy, 3, Met. 106

Second Semester

Chemistry 144, Electrochemistry, 5, Chem. 102
Chemistry 24, Iron and Steel Analysis, 7, Chem. 12
Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Mechanics 18, Mill and Smelter Design, 10, Mech. 15
Metallurgy 152, Metallography, 6, Met. 106

Metallurgy 12, Special Problems, 4; Met. 7
Metallurgy 14, Thesis, 10, Met. 11

FOUR-YEAR COURSES

JUNIOR YEAR

First Semester

Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 73, Historical and Economic Geology, 3, Geol. 105, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 3, Math. 8
Metallurgy 105, Base Metals, 4, Met. 4
Mining Engineering 7, Ore Dressing, 5, Geol. 106
Mining Engineering 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Smelter Work, beginning about June 1

SENIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Metallurgy 11, Special Problems, 8, Met. 106, Min. 8
Metallurgy 109, Electrometallurgy, 3, Met. 106

Second Semester

Chemistry 144, Electrochemistry, 5, Chem. 102
Chemistry 24, Iron and Steel Analysis, 7, Chem. 12
Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Mechanics 18, Mill and Smelter Design, 10, Mech. 15
Metallurgy 152, Metallography, 6, Met. 106
Metallurgy 12, Special Problems, 4, Met. 7
Metallurgy 14, Thesis, 10, Met. 11

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in Metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags are shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their reports in detail. This work is offered to students completing the necessary courses in Mineralogy and Chemistry.

ORE TESTING

The lectures treat of the use and purposes of all the machinery connected with the subject, supplemented by detailed drawings. There are complete testing works, connected with the department where the student may see the working of, and handle for himself crushers, rolls, Huntington mill, concentrating machinery, such as vanners, buddles, jigs, pan for amalgamation, settlers, reverberatory furnaces for oxidizing and oxidizing-chloridizing roasts, leaching and chlorination plants, as well as sizing apparatus and hydraulic separators. Sufficiently large amounts of ore are given to make the necessary tests upon the different machines and the students report the best method of treatment. The first semester of the senior year is devoted to instruction and laboratory work, and is required of students both in Mining and Metallurgy.

The ore-testing works meet educational, as well as commercial, needs.

Educational.—The ore-testing plant acquaints the student with the construction and manipulation of the principal typical machines used in the leading ore-dressing establishments of the country. It is here that students in Mining and Metallurgical Engineering get the requisite practical experience. They handle all machines and operate on sufficiently

large amounts of material to determine the methods best suited to a given ore to extract the largest amount of metal with the least possible loss.

Commercial.—Ore-testing works are an important factor in mining and metallurgical projects. The commercial object is to determine the best method of treating a given ore so as to yield the largest percentage of the metal it contains at the least possible cost. Samples varying from 500 pounds to car-load lots can be treated by various methods.

As the funds appropriated for the erection of such a plant were sufficient to purchase only the necessary machinery, the business men of Minneapolis generously provided a suitable building. This building, 94 by 66 feet, is built of brick and stone.

Machinery.—The plant contains all the machinery necessary to illustrate the various processes of ore testing, viz., a Bridgman mechanical sampler size B; a link belt bucket elevator; a pulley feeder complete; a pair of 12½ by 12 geared rolls complete; a four compartment spitzkasten; a three compartment Hartz jig; a Collum jig complete with cone for driving; a three and a half foot Huntington mill complete; a three-stamp mill, 275-pound stamps; a five-stamp mill, 850-pound stamps; a Challenge automatic feeder for five-stamp battery; a suspended Challenge feeder for three-stamp battery; a Tulloch feeder for Huntington mill; a single deck buddle, twelve feet in diameter; a four-foot plain belt Frue vanner; a Cammett concentrator; a Hooper pneumatic concentrator; a Century drop motion jig; a three-foot amalgamating pan; a five-foot settler; a Bruckner roasting furnace, with fire box on wheels; a chlorination barrel; a battery tightener; a two-horse-power vertical boiler; a steam drying pan; three trommels, with driving arrangement and gears; a one-thousand pound Reedy elevator, complete with worm gear; two overhead crawls, each with eighty-foot track; one-ton pulley block; a quarter-ton pulley block; a scoop car, with flat wheels; two twenty-horse-power electric motors; three MacDermott automatic samplers, etc.

FIELD WORK IN METALLURGY

At the end of the junior year opportunity is given the student to study metallurgical operations at one or more smelting works. This work will begin about May 1. Not over two weeks' time will be devoted to this work.

Upon termination of the junior field work in Metallurgy and two weeks in Mining (not later than June 1), the members of the junior class who are candidates for the degree of Metallurgical Engineer, are required to spend at least six weeks in practical work in one or more of the smelters of the West, for which they may receive wages. The department will render all possible assistance in locating students in the camps of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must, in person, submit this diary to the department on date of reopening of field work. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department

reserves the right to reject note-books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 7, 1915. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering field work in Metallurgy and Mining must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: Metallurgy, September 7-14, inclusive; Mining, September 15-27.

On September 27 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with sketches drawn to scale covering all the metallurgical and milling operations, together with details of plant and equipment. Final registration will not be allowed until after final report on field work is made. All final reports, therefore, must be presented on or before September 27. These reports shall become the property of the School.

METALLOGRAPHY

Courses in Metallography are offered to seniors who are candidates for the degree of Metallurgical Engineer, students in the Colleges of Science, Literature, and the Arts, Engineering, Chemistry, and the Graduate School.

These courses deal with the microscopic examination of metals, alloys, and ores. The lectures treat of and describe the apparatus used in connection with this subject, the methods of preparing specimens, the physical, chemical, and metallurgical principles involved, and the interpretation of the results of microscopic examination. A collection of specimens, micro-photographs, and lantern slides covering wrought iron, low carbon, structural, rail, and tool steels, brasses, bronzes, and other industrial alloys are available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals, alloys, and ores. The laboratory is equipped with microscopes, electric and portable gas furnaces, and pyrometers of the latest and improved types. A special dark room is available for the preparation of microphotographs.

DEPARTMENTAL STATEMENTS

CHEMISTRY

Professors George B. Frankforter, Charles F. Sidener; Assistant Professor Francis C. Frary; Instructors Earl Pettijohn, Woldemar M. Sternberg, Sterling Temple.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
5.	Gen. & Anal. Chemistry	3	2	All Fr.	..
6.	Gen. & Anal. Chemistry	1	6	All Fr.	5
11.	Quantitative Analysis	1	6	All Soph.	6
12.	Quantitative Analysis	1	6	All Soph.	11
24.	Iron & Steel Analysis	1	6	Sr. Met. E.	12
25.	Ore & Slag Analysis	1	6	Sr. E. M. & Met. E.	12
144.	Electrochemistry	1	4	Sr. Met. E.	12

5-6. General and Analytical Chemistry. An introduction to descriptive, physical, and metallurgical chemistry and qualitative analysis. Frankforter, Temple, and Assistants.

11-12. Quantitative Analysis. The course includes a general discussion of quantitative methods, with laboratory work in gravimetric analysis, first semester, followed by a discussion of standard solutions and the necessary stoichiometric calculations with laboratory work in volumetric analysis, second semester. Sidener, Pettijohn, Sternberg, and Assistants.

24. Iron and Steel Analysis. Includes technical methods for the determination of the common constituents of iron ores, iron, and steel, with training in rapid work. Sidener, Pettijohn, and Sternberg.

25. Ore and Slag Analysis. Rapid technical method for the determination of certain constituents in ores and slags. Sidener, Pettijohn, and Sternberg.

144. Electrochemistry. A discussion of electro-analytical methods and industrial electrochemical processes, and their underlying principles. Frary.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor William H. Kirchner; Instructors Robert W. French, Frank B. Rowley.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11.	Engineering Drawing	..	10	All Fr.	
12.	Engineering Drawing	..	8	All Fr.	11
13.	Descriptive Geometry	2	..	All Soph.	12, Math. 6
14.	Drafting	..	4	All Soph.	13

11. Engineering Drawing. Sketching, lettering, representation, parallel and radial projection, elements of engineering, representation of details of machines and structures, interpretation of working drawings. Kirchner, French.

12. Engineering Drawing. Continuation of Course 11 as outlined above. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Maps and sketches. Brush and pen conventions. Rowley, French.

13. Descriptive Geometry. Projection: central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. Kirchner.

14. Drafting. Graphics, machine drafting, and structural drafting. Instruction in drafting room methods. French.

ELECTRICAL ENGINEERING

Professor George D. Shepardson; Assistant Professor William T. Ryan.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
53.	Electric Power	2	2	Sr. E. M. & Met. E.	Physics 3, 4

53. Electric Power. Elements of theory and practice of electrical measurements, wiring, dynamos, motors, and electric lighting. Ryan.

EXPERIMENTAL ENGINEERING

Professor William H. Kavanaugh; Assistant Professors Charles F. Shoop, Franklin R. McMillan.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
21.	Steam Laboratory	..	4	Jr. E. M. & Met. E.	With Math. 11
22.	Strength of Materials	..	4	Jr. E. M. & Met. E.	With Math. 10
24.	Experimental Laboratory	..	4	Sr. E. M. & Met. E.	21

21. Steam Laboratory. Exercises in valve setting, indicator practice, calibration of steam gauges, efficiency of screws and hoists. Shoop.

22. Strength of Materials. Laboratory work, investigating the strength and physical qualities of iron, steel, brass, copper, belting, chains, beams, brick, and stone. McMillan.

24. Experimental Laboratory. Hydraulic measurements. Calibration of weirs, nozzles, meters, and other hydraulic apparatus, calorimetry; tests of pumps, engines, and boilers. Kavanaugh.

GEOLOGY AND MINERALOGY

Professor William H. Emmons; Associate Professor Clinton R. Stauffer; Assistant Professor Frank F. Grout; Instructors A. Walfred Johnston, Edgar K. Soper; Assistants T. M. Broderick, J. P. Goldsberry.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1b.	General Geology	3	..	All Soph.	24
1f.	Field Work	..	2 wks	All Soph.	1b and 105
23.	Elements of Mineralogy	4	4	All Fr.	..
24.	Descriptive Mineralogy	2	2	All Fr.	23
57.	Paleontology	3	..	Jr. E. M. (Geol.)	1b
58.	Paleontology	3	..	Jr. E. M. (Geol.)	57
73.	Histor. & Econ. Geology	3	..	All Jr.	1b and 105
105.	Elements of Rock Study	..	4	All Soph.	24
106.	Petrology	..	4	All Soph.	105b
111.	Ore Deposits	4	..	Sr. E. M. & E. M. (Geol.)	106
112.	Problems in Ore Deposits	..	4	Sr. E. M. & E. M. (Geol.)	111
113.	Laboratory Course in Econ. Geology	..	4	Sr. E. M. (Geol.)	With 111
124.	Struct. & Metamorph. Geol.	3	..	Jr. E. M. (Geol.)	73 and 105
138.	Testing Econ. Minerals	..	4	Elective	24 and 73
144.	Construction & Interpretation of Geologic Maps	..	4	Elective	73
151.	Advanced General Geology.	3	..	Sr. E. M. (Geol.)	73
152.	Advanced General Geology.	3	..	Sr. E. M. (Geol.)	151

1b. General Geology. A synoptical treatment of materials of the earth and of geologic processes. Physiographic, dynamic, and structural geology, with a brief introduction to Historical Geology. Johnston.

1f. Field Work. A two-week excursion to the Iron Ranges for practice in field methods, such as tracing contacts, working out structures and constructing and interpreting geologic maps. Johnston and Assistants.

23. Elements of Mineralogy. The crystal systems; morphological, physical, and chemical character of minerals; occurrence, genesis, and uses of minerals; classifications and description of common minerals. Determinative work in laboratory, blowpipe analysis, sight identification. Broderick, Goldsberry.

24. Descriptive Mineralogy. A continuation of Course 23, special attention being given to metalliferous and rock-forming minerals. Laboratory determination and sight identification. The use of the goniometer and microscope. Laboratory work, reference reading, and field excursions. Broderick, Goldsberry.

57. Paleontology. A study of fossil forms with special reference to those of geological importance. Stauffer.

58. Paleontology. Faunas and their correlation. A continuation of Course 57. Stauffer.

73. Historical and Economic Geology. (a) Historical Geology. The geologic history of North America, with special references to its syngenetic mineral deposits. (b) Economic Geology. A study of the non-metallic minerals of economic value, and discussions of the geologic guides to prospecting for these deposits. Emmons, Soper.

105. Elements of Rock Study. The occurrence and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. Broderick.

106. Petrology. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and metamorphic rocks. The origin and classification of rocks. Broderick.

111. Ore Deposits. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. Emmons, Soper.

112. Problems in Ore Deposits. Field excursions, map work, lectures on field and laboratory methods. Emmons, Soper.

113. Laboratory Course in Economic Geology. A study of ores, rocks and geological structure of selected American and foreign mining districts. Correlated reading. Emmons.

124. Structural and Metamorphic Geology. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. Johnston.

138. Testing Economic Minerals. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, oil, building stone, and metallic ores.

144. Construction and Interpretation of Geologic Maps. Hours to be arranged. Methods of geological examination; problems in construction and interpretation of geologic maps and sections, with special reference to underground mapping of metalliferous areas; field practice in plane table methods of topographic and geologic mapping. Soper.

151. Advanced General Geology. Geologic processes and their results; development of the North American continent. Stauffer.

152. Advanced General Geology. A continuation of Course 151. Stauffer.

GERMAN

Professor Carl Schlenker; Assistant Professors Oscar C. Burkhard, Walter R. Myers; Instructors J. Theodore Geissendoerfer, Richard Wischkaemper.

COURSES

No.	Title	Lect. or rec. hrs.	Required of	Prereq. courses
15.	Beginning German	3	Jr. E. M. (Geol.)	..
16.	Beginning German	3	Jr. E. M. (Geol.)	15
17.	Scientific Intermediate	3	Jr. or Sr. E. M. (Geol.)	16
18.	Scientific Intermediate	3	Jr. or Sr. E. M. (Geol.)	17
23.	Advanced Scientific	3	Sr. E. M. (Geol.)	18
24.	Advanced Scientific	3	Sr. E. M. (Geol.)	23

15-16. Beginning. Pronunciation, grammar, conversation, and composition; selected reading in easy prose and verse. Burkhard.

17-18. Scientific Intermediate. This course is arranged to meet the needs of students in the School of Mines. Text: Merckel's *Bilder aus der Ingenieurtechnik*. Burkhard, Myers.

23-24. Advanced Scientific Reading. Reading of monographs and periodicals. Geissendoerfer, Wischkaemper.

MECHANICAL ENGINEERING

Professor John J. Flather; Assistant Professor S. Carl Shipley; Instructors Peter Peterson, Edward Quigley, William H. Richards.

COURSES

No.	Title	Lab. hrs.	Required of	Prereq. courses
1a.	Pattern Making	6 (9 wks)	1st-yr. E. M. & Met. E.	..
1b.	Foundry	6 (9 wks)	1st-yr. E. M. & Met. E.	..
1c.	Forge	6 (9 wks)	1st-yr. E. M. & Met. E.	..
1d.	Machine & Bench Work	6 (9 wks)	1st-yr. R. M. & Met. E.	..

1a. Pattern Making. Use of tools, lathe and bench work, making of timber joints, core boxes and flasks. Richards, Ubrich.

1b. Foundry. Molding, core making, mixing and casting metals. Peterson.

1c. Forge. Use of tools, forging, welding, tool dressing and tempering. Quigley.

1d. Machine and Bench Work. Use of tools and elementary machine operations. Shipley.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Assistant Professor Samuel L. Hoyt.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
2.	Assaying	4	8	All Fr.	Chem. 5, Mineral, 23
3.	Gen. Met. & Iron and Steel.	3	..	Soph. E. M. & Met. E.	2, Chem. 6

No.	Title	Lect. or rec. hrs.		Required of	Prereq. courses
4.	Wrought Iron & Steel	3	..	Soph. E. M. & Met. E.	3
6f.	Field Work in Metallurgy	..	10 dys	Jr. E. M. & Met. E.	Satisfactory completion of Jr. year
7.	Ore Testing	2	8	Sr. E. M. & Met. E.	106, Min. 7
8.	Metallurgy	3	..	Soph. E. M. (Geol.)	2
11.	Special Problems in Met	..	8	Sr. Met. E.	106, Min. 7
12.	Special Problems in Met	..	4	Sr. E. M. & Met. E.	106, Min. 7
14.	Thesis and Specifications	..	10	Sr. Met. E.	11
105.	Met. of Base Metals	4	..	Jr. E. M. & Met. E.	4
106.	Met. of Precious Metals	4	..	Jr. E. M. & Met. E.	105
109.	Electrometallurgy	3	..	Sr. Met. E.	106
152.	Metallography	2	4	Sr. Met. E.	106
153.	Metallography	3	4	Elective	Chem. 12, Phys. 1 and 2
154.	Metallography	3	4	Elective	153
155.	Metallog. for Geologists	2	2	Elective	Geol. 4, 5 & 18
156.	Metallog. for Geologists	2	2	Elective	155
157.	Metallog. for Engineers	2	4	Elective	Mech. Eng. 3 and 4
160.	Metallog. for Chemists	2	2	Elective	Chem. 12, Phys. 1 and 2
162.	Ad. Metallog. for Eng	2	4	Elective	157
163.	Dental Metallog	3	..	Elective	..
201.	Ad. Metallog	To be ar.		Elective	154
202.	Ad. Metallog	To be ar.		Elective	201

2. Assaying. Determination of values of ores, metallurgical products, and bullion. Appleby and Assistants.

3. General Metallurgy and Metallurgy of Iron. Including the subjects of combustion, fuels, refractory materials and furnaces. Lectures and recitations on metallurgy of iron. Christianson.

4. Metallurgy of Wrought Iron and Steel. Consideration of the principles of manufacture, details of plant construction, and chemical and physical phenomena. Christianson.

6f. Field Work in Metallurgy. Study of metallurgical operations at smelters and mills. Detailed report is required covering plants visited. Christianson, Pease.

7. Ore Testing. Determinations of methods of ore treatment, stamping, concentration, cyanidation, roasting, chlorination, lixiviation, and amalgamation. Appleby and Assistants.

8. Metallurgy. A short course covering the metallurgy of the principal metals. Pease.

11. Special Problems in Metallurgy. Research work preparatory to thesis. Appleby and Assistants.

12. Special Problems in Metallurgy. Pease.

14. Thesis and Specifications. Detailed investigations of ore treatment

with report including designs and specifications for suitable plants. Appleby, Comstock, and Assistants.

105. Metallurgy of the Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining methods. Pease.

106. Metallurgy of the Precious Metals. Gold, silver, and platinum. Methods and principles of cyanidation, chlorination, amalgamation, and lixiviation as applied to the treatment of the above. Pease.

109. Electrometallurgy. A study of the reduction of ores, refining of metals, and production of metals by electrolytic deposition; and the use of the electric furnace for smelting of ores, refining metals, and the manufacture of refractory alloys. Christianson.

152. Metallography. A study of the microstructure of metals and alloys as affected by heat and industrial treatments, together with the influence of changes of structure on their properties. Special attention is given to siderurgic products. Hoyt.

153-154. Metallography. The microscopical and thermal analysis of metals and alloys. Metallographic technique. The physical and chemical properties of metals and alloys. The commercial alloys, their heat and other industrial treatments. The metallography of iron and steel. Hoyt.

155-156. Metallography Applied to the Study of Geology. Application of metallographical principles and methods of research to geology, with special attention to the genesis of rocks and ore bodies. The microscopical examination of opaque minerals by reflected light. Hoyt.

157. Metallography for Engineering Students. Metallurgy of iron and steel. Microscopic and thermal analysis of steel and cast iron; heat and mechanical treatment. The properties of iron and steel as affected by composition and treatment. Laboratory work. Hoyt.

160. Metallography for Chemical Students. The preparation of metallic alloys; their microscopical and thermal analysis. Steel and other commercial alloys with particular reference to chemical metallurgy. Corrosion of steel and non-ferrous alloys. Metallography applied to analytical chemistry. Hoyt.

162. Advanced Metallography for Engineering Students. Metallography applied to engineering practice; machine design, structural engineering, electrical engineering. Engineering specifications involving the use of metals and alloys. Hoyt.

163. Dental Metallography. Study of the dental alloys from the standpoint of metallography. Hoyt.

201-202. Advanced Metallography. Technical and scientific research. The study of steel rails, automobile and locomotive parts, tool steels, etc. Special problems in metallography with outside reading. Seminar work on the recent advances in metallography. Hoyt.

MINE PLANT AND MECHANICS

Professor Elting H. Comstock; Assistant Professor Edwin M. Lambert; Instructor Edward W. Davis.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Computation & Mensuration	3	..	All 1st-yr. students	..
3.	Mine Accounting	..	6	All 1st-yr. students	..
4.	Algebra	4	..	All 1st-yr. students	..
5.	Algebra & Trigonometry	6	..	All Fr.	1 & 2
6.	Spherical Trig. & Anal. Geom.	6	..	All Fr.	5
7.	Calculus	5	..	All Soph.	6
8.	Calculus	3	..	All Soph.	7
9.	Mechanics	5	..	All Jr.	8
10.	Mechanics	6	..	All Jr.	9
11.	Mine Plant	3	..	Jr. E. M. & Met. E.	8
12.	Mine Plant	6	..	Jr. E. M. & Met. E.	11
13.	Hydraulics & Water-Power	5	..	All Sr.	10
15.	Engineering Construction	1	4	Sr. E. M. & Met. E.	10
16.	Mine Plant Design	..	10	Sr. E. M.	15
18.	Mill and Smelter Design	..	6	Sr. Met. E.	15

1. Computation and Mensuration. Demonstrations of most important theorems of solid geometry. Volumes, approximate volumes, prismoidal formula, etc. Approximate computation, graphs, and graphical computation, logarithms and logarithmic computation, areas and approximations of areas, use of slide rule. Davis.

3. Elementary Mine Accounting. Elementary accounting in general; applications to mine accounts; primary records, labor, supply, mine and mill products, and fund sheets; secondary records, invoice, labor and supply, mine and mill cost sheets, trial balance. Lambert.

4. Algebra. Equations with one, two, or more unknown quantities, inequalities, involution and evolution, theory of exponents, surds, quadratic equations both numerical and literal, equations with one or more unknown quantities that can be solved by means of quadratic equations, progressions. Davis.

5. Algebra and Trigonometry. Functions and functional notation, factor and remainder theorems, factors and values of functions, determinants, development of functions, theory of equations, permutations and combinations; trigonometric ratios, right triangles, general definitions of trigonometric functions, analytic relations, addition formulas, trigonometric equations, and oblique triangles. Davis.

6. Spherical Trigonometry and Analytical Geometry. General proper-

ties and solution of spherical triangles; systems of coördinates, loci, equations and properties of the straight line, transformation of coördinates, equations and properties of conics, general equations of the second degree, higher plane curves, space coördinates, point, plane, straight line, quadric surfaces. DAVIS.

7. CALCULUS. Nature of differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, indeterminate forms, partial derivatives, change of variable. LAMBERT.

8. CALCULUS. Elementary integration, undetermined coefficients, rational fractions, rationalization, formulas of reduction, hyperbolic functions, some differential equations of mechanics. LAMBERT.

9. MECHANICS. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy; elementary mechanics of materials. LAMBERT.

10. MECHANICS. Mechanical and elastic properties of materials of construction; beams, shafts, columns, reinforced concrete, hollow cylinders and spheres, rollers, plates; theory of internal stress. LAMBERT.

11-12. MINE PLANT. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. COMSTOCK.

13. HYDRAULICS AND WATER-POWER. Laws of the equilibrium, pressure, and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, speed control, power-house equipment, transmission. COMSTOCK.

15. ENGINEERING CONSTRUCTION. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures, design of mining structures. COMSTOCK.

16. MINE PLANT DESIGN. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. COMSTOCK.

18. MILL AND SMELTER DESIGN. A study of the construction and mechanical equipment of mills and smelters in connection with thesis work. COMSTOCK.

MINING ENGINEERING

Professors GEORGE J. YOUNG, EDWARD P. MCCARTY; Instructors ERVIN W. MCCULLOUGH, JOHN F. MURPHY.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Mine Surveying	3	..	All Soph.	Math. 6
2.	Mine Surveying	3	..	All Soph.	1
2f.	Field Work	..	7 wks	All Soph.	2
4.	Mine Mapping	..	6	All Jr.	2f
6.	Mining	1	..	All Soph.	..
7.	Ore Dressing	5	..	All Jr.	..
9.	Mining	5	..	All Jr.	6
10.	Mining	5	..	All Jr.	9
10f.	Practical Mining	..	2 wks	All Jr.	Satisfactory completion of Jr. year
11.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	10
12.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	11
13.	Thesis	..	2	Sr. E. M.	10f
14.	Thesis	..	8	Sr. E. M.	13

1, 2. MINE SURVEYING. Computation, platting, and problems with special reference to mine surveying. MURPHY.

2f. FIELD WORK. Practice in general surveying during the month of May. Practice in underground surveying during the first two weeks of June. This work is given on the Iron Ranges. McCARTY, MURPHY.

4. MINE MAPPING. Mine mapping in accordance with prevalent practice in the western mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. MURPHY.

6. MINING. Examination and testing, and use of explosives. McCULLOUGH.

7. ORE DRESSING. Examination of ores, crushing, sizing classification, and methods of mechanical separation. McCULLOUGH.

9. MINING. Occurrence of ore bodies, prospecting, churn and diamond drilling, drilling, blasting, excavation, surface transportation, tunneling and drifting. YOUNG.

10. MINING. Shaft-sinking, support of underground excavations, hoisting, drainage, ventilation, underground transportation. YOUNG.

10f. PRACTICAL MINING. Study of mining operations. Mine plant and equipment and practical mining work; a mine to be selected by department during months of May, June, July, and August. YOUNG, COMSTOCK, and Assistants.

11. MINING. Open pit, quarrying, underground methods, coal mining, mining alluvial deposits. YOUNG.

12. MINING. Mine management, mining law, economics of mining, mine examination, mine sanitation and hygiene. YOUNG.

13, 14. THESIS. Conference. Design and specifications of mining details required in thesis study. YOUNG.

PHYSICS

Professors Henry A. Erikson, Anthony Zeleny;* Instructor Paul E. Klopsteg.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	General Physics	3	..	All Soph.	Math. 6
2.	General Physics	3	..	All Soph.	1
3.	General Lab. Practice	..	2	All Soph.	With 1
4.	General Lab. Practice	..	2	All Soph.	With 2

1. General Physics. Mechanics of solids and fluids, sound and heat. Treatment experimental rather than mathematical; the fundamental principles. Erikson, Klopsteg.

2. General Physics. Light, electricity, and magnetism. Treatment experimental; the fundamental principles, including those of radioactivity, ionization, X-radiation, and the electrical constitution of matter. Erikson, Klopsteg.

3. General Laboratory Practice. Physical measurements in the mechanics of solids and fluids, and in heat and sound, giving the student a knowledge of experimental methods, and an intimate acquaintance with the fundamental facts of the subject. Erikson.

4. General Laboratory Practice. Physical measurements in light, electricity, and magnetism. Erikson.

ROMANCE LANGUAGES

Professor Everett Ward Olmsted; Assistant Professor Jules T. Frelin; Instructors E. H. Sirich, Herbert K. Stone; Assistant Homer Desmarais.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
1.	Beginning French	3	Jr. E. M. (Geol.)	..
2.	Beginning French	3	Jr. E. M. (Geol.)	1
3.	Intermediate French	3	Jr. or Sr. E. M. (Geol.)	2
4.	Intermediate French	3	Jr. or Sr. E. M. (Geol.)	3
5.	Survey French Lit	3	Sr. E. M. (Geol.)	4
6.	Survey French Lit	3	Sr. E. M. (Geol.)	5

1-2. Beginning French. Stress on accurate pronunciation, reading, reading vocabulary, and the essentials of grammar. Daily oral and written exercises (dictation and reproduction in French). Desmarais.

3-4. Intermediate. French grammar, composition, and reading; increased use of French in the classroom. Selections from modern prose and poetry. Frelin, Desmarais.

5-6. General Survey of French Literature. Lectures, recitations, and assigned readings. Designed to cover the whole period in historical outline. Selections from representative authors. Olmsted.

*Absent on leave, 1915-16.

STUDENTS

SENIORS—15

Butler, W. Victor, Minneapolis
Christenson, Alfred, Madelia
Clark, Malcolm W., Northfield
Coller, Walter A., St. Paul
Collins, Leon T., Pine Island
Haugan, Albert C., Hanska
Harmon, Sydney, St. Paul
Heilig, Louis S., Minneapolis
Johnson, Fred C., Willmar
Kerr, Charles D., Little Falls
Neerland, Herman,
Sanchez, Richard M., Tarma, Peru, S. A.
Urquhart, George K., St. Paul
Wade, Henry R., Hopkins
Williams, Paul S., Minneapolis

JUNIORS—12

Abrahamson, Hjalmar, Wadena
Aronson, Sam, St. Paul
Buresch, Charles E., Lakefield
Craig, John J., Minneapolis
Davies, Fred A., Minneapolis
Dovre, Adolph, Sleepy Eye
*Field, Reginald, Mobridge, S. D.
Krogh, Alvin T., Minneapolis
Lee, Oscar, St. Paul
McDermid, Archie J., Duluth
McHardy, Roy H., Minneapolis
Nord, Harry H., Ashland, Wis.

SOPHOMORES—20

Anderson, Edwin H., Oakes, N. D.
Breslauer, Mirton B., Spokane, Wash.
Capser, Leo W., St. Paul
Cassily, Thomas E., St. Paul
Coryell, Lewis S., Osceola, Wis.
Dennis, Richard C., Ashland, Wis.
Elson, William H., St. Paul
Ernster, Omer F., Brainerd
Fearing, Edward J., Little Falls, Minn.
Frank, Harry, Minneapolis
Hicks, John, St. Paul
Levorsen, A. Irving, Fergus Falls
Kwong, Yih-Kum, Shanghai, China
Nichols, Clifford R., Buhl, Minn.
Peterson, Paul A., St. Paul
Shattuck, Warner A., Bisbee, Ariz.
Strand, Harry W., Marine Mills
Sweetman, Edwin A., Aitkin
Wallace, Carleton S., Minneapolis
Woodruff, John J., Minneapolis

FRESHMAN—30

Ainsworth, Robert E., Minneapolis
Allard, Raymond W., St. Paul
Armstrong, Harold H., Minneapolis
Bailey, A. Kittredge, Minneapolis
Bradt, Harlan H., Minneapolis
Caswell, Alexis, Jr., Minneapolis
Clark, Fred E., Minneapolis
Copeland, William A., St. Paul
Cowin, Percy G., Minneapolis
Cutler, F. A., Jr., Minneapolis
Dane, Carleton M., St. Paul
Dowdell, Ralph L., St. Paul
Foley, Lyndon L., Minneapolis
Gannett, Roger W., Minneapolis
Hauser, Karl W., St. Paul
Hauser, Louis A., St. Paul
Hurley, Frank W., St. Paul
Ingersoll, Guy E., Hibbing
Jerrard, Walter L., St. Cloud
Johnson, Russell V., Lanesboro
Kulberg, Sam, Minneapolis
McGilvra, Donald B., Minneapolis
Moga, John A., St. Paul
Quinn, Howard E., Melrose
Ringwood, Thomas E., Ashland, Wis.
Rosenberg, Maurice M., Minneapolis
Sinclair, Gilbert, Minneapolis
Sponberg, Edwin C., Hibbing
Stickney, Robert A., Inglewood, N. J.
Sullivan, Daniel C., Stillwater

FIRST YEAR—9

Abramson, Jake, Minneapolis
Alverson, Miles C., Medford, Wis.
Donaghue, Abner J., Minneapolis
Hollister, Paul M., Madison, S. D.
Hoving, George E., Fergus Falls
Kersten, Erwin H. W., Minneapolis
Rye, Hjalmer, Aurora
Scott, Wendell K., St. Cloud
Wadsworth, Lawrence H., Minneapolis

*Deceased.

Bulletin of
The University of Minnesota

THE SCHOOL OF MINES

1916-1917

VOL. XIX. NO. 10 MAY 1916

Entered at the Post-Office
in Minneapolis as second-class matter
Minneapolis, Minn.

1916

JULY

Su	Mo	Tu	W	Th	Fr	Sa
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AUGUST

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1917

JANUARY

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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UNIVERSITY CALENDAR

1916-1917

The University year covers a period of thirty-eight weeks. Commencement Day is always the second Thursday in June.

1916			
September	13	Wednesday	Registration closes except for new students
September	13-20	Week	Fees payable except for new students
September	19-26	Week	Examinations for the removal of conditions (except Colleges of Agriculture and Forestry), entrance examinations, registration of new students, and payment of fees.
September	27	Wednesday	First semester begins
October	2	Monday	Agricultural College, farm experience examinations
October	2	Monday	School of Agriculture, first term begins
October	5	Thursday	Senate meeting, 4:00 p.m.
November	6	Monday	Dairy School closes
November	7	Tuesday	Election day; a holiday
November	22	Wednesday	Medical School second quarter begins
November	29	Wednesday	Thanksgiving recess begins 9:00 p.m
December	2	Saturday	Dairy School closes
December	4	Monday	Thanksgiving recess ends 8:00 a.m.
December	4-9	Week	Second semester condition examinations, Colleges of Agriculture and Forestry
December	4-9	Week	Short course for ice-cream makers
December	7	Thursday	Senate meeting, 4:00 p.m.
December	22	Friday	Christmas vacation begins 9:00 p.m.
December	22	Friday	School of Agriculture, first term closes
1917			
January	1-6	Week	Farmers' Short Course
January	3	Wednesday	Christmas vacation ends 8:00 a.m.
January	3	Wednesday	School of Embalming begins, eight weeks' session
January	9	Tuesday	School of Agriculture, second term begins
January	24	Wednesday	Second semester registration closes, except for new students
January	29	Monday	Final examinations begin
January	31	Wednesday	Payment of fees for second semester closes, except for new students
February	1	Thursday	Senate meeting, 4:00 p.m.
February	5-6	Monday-Tues.	Registration and payment of fees for new students

February	7	Wednesday	Second semester begins
February	12	Monday	Lincoln's Birthday; a holiday
February	22	Thursday	Washington's Birthday; a holiday
March	28	Wednesday	School of Agriculture closes
April	2-7	Week	Junior Short Course
April	5	Thursday	Easter recess begins 9:00 p.m.
April	11	Wednesday	Easter recess ends 8:00 a.m.
April	11	Wednesday	Medical School fourth quarter begins
April	16-21	Week	Condition examinations in certain colleges
May	1	Tuesday	Traction Engineering Course begins
May	3	Thursday	Senate meeting, 4:00 p.m.
May	30	Wednesday	Memorial Day; a holiday
June	1	Friday	Final examinations begin 2:00 p.m.
June	7-14	Week	Military Encampment, Fort Snelling
June	9	Saturday	Second semester closes
June	10	Sunday	Baccalaureate service
June	11	Monday	Senior Class Day exercises
June	13	Wednesday	Alumni Day
June	14	Thursday	Forty-fourth Annual Commencement
June	15	Friday	Summer vacation begins
June	18	Monday	Summer Session begins

The University year for 1917-1918 will begin Tuesday, September 18.

Program of Supplementary Examinations

Tuesday,	Sept. 19	9-12 a.m.	Mechanics and Mathematics
		2-5 p.m.	Mining Engineering Subjects
Wednesday,	Sept. 20	9-12 a.m.	Chemistry
		2-5 p.m.	Drawing and Descriptive Geometry
		2-5 p.m.	Mechanical Engineering Subjects
Thursday,	Sept. 21	9-12 a.m.	Metallurgical Subjects
		2-5 p.m.	Physics
Friday,	Sept. 22	9-12 a.m.	Electrical Engineering Subjects
		2-5 p.m.	Geology and Mineralogy

THE SCHOOL OF MINES

FACULTY

George Edgar Vincent, Ph.D., LL.D., President — 1005 5th St. S. E.
Cyrus Northrop, LL.D., President Emeritus — 519 10th Ave. S. E.
William R. Appleby, M.A., Dean and Professor of Metallurgy — 928 5th St. S. E.
....., Professor of Mining
Oscar C. Burkhard, M.A., Assistant Professor of German — 719 E. River Road
Peter Christianson, B.S., E.M., Professor of Metallurgy — 217 Union St. S. E.
Elting H. Comstock, M.S., Professor of Mine Plant and Mechanics — 1416 7th St. S. E.
William H. Emmons, Ph.D., Professor of Mineralogy and Geology — 611 11th Ave. S. E.
Henry A. Erikson, Ph.D., Professor of Physics — 424 Harvard St. S. E.
John J. Flather, Ph.B., M.M.E., Professor of Mechanical Engineering — 315 11th Ave. S. E.
George B. Frankforter, Ph.D., Professor of Chemistry — 525 E. River Road
Jules T. Frelin, B.A., Assistant Professor of Romance Languages — 1206 5th St. S. E.
Frank F. Grout, M.S., Assistant Professor of Geology and Mineralogy — 617 4th St. S. E.
Samuel L. Hoyt, E.M., Ph.D., Assistant Professor of Metallography — 1011 14th Ave. S. E.
William H. Kavanaugh, M.E., Professor of Experimental Engineering — 124 State St. S. E.
William H. Kirchner, B.S., Professor of Drawing and Descriptive Geometry — 722 10th Ave. S. E.
Edwin M. Lambert, M.E., Assistant Professor of Mine Plant and Mechanics — 1086 12th Ave. S. E.
Edward P. McCarty, E.M., Professor of Mining — 3615 Lyndale Ave. S.
Franklin R. McMillan, C.E., Assistant Professor of Structural Engineering — 524 8th Ave. S. E.
Everett W. Olmsted, Ph.D., Professor of Romance Languages — 901 5th St. S. E.
Levi B. Pease, M.S., Professor of Metallurgy — 1070 16th Ave. S. E.
William T. Ryan, E.E., Assistant Professor of Electrical Engineering — 3228 4th St. S. E.
Carl Schlenker, B.A., Professor of German — 514 11th Ave. S. E.
George D. Shepardson, M.A., M.E., D.Sc., Professor of Electrical Engineering — 717 E. River Road

S. Carl Shipley, B.S., M.E., Assistant Professor of Machine Construction 1517 E. River Road
Charles F. Shoop, B.S., Assistant Professor of Experimental Engineering 811 Fulton St. S. E.
Charles F. Sidener, B.S., Professor of Chemistry 1320 5th St. S. E.
Clinton R. Stauffer, Professor of Geology 1023 University Ave. S. E.
Anthony Zeleny, Ph.D., Professor of Physics 613 Fulton St. S. E.
Charles H. Blitman, C.E., Instructor in Drawing 1318 7th St. S. E.
Edward W. Davis, B.S., Instructor in Mechanics and Mathematics 979 14th Ave. S. E.
E. O. Dieterich, Ph.D., Instructor in Physics 809 Essex St. S. E.
Gerhard Dietrichson, Ph.D., Instructor in Chemistry 429 Walnut St. S. E.
Robert W. French, B.S., Instructor in Drawing 1018 16th Ave. S. E.
J. Theodore Geissendoerfer, Ph.D., Instructor in German 967 14th Ave. S. E.
A. Walfred Johnston, M.A., Instructor in Geology 803 University Ave. S. E.
Ervin W. McCullough, E.M., Instructor in Metallurgy 934 E. Bayliss Ave., St. Paul
John F. Murphy, C.E., Instructor in Mining 619 University Ave. S. E.
Edmund Newton, E.M., Instructor in Metallurgy 941 14th Ave. S. E.
Edward P. Quigley, Instructor in Forge Work 2923 Chicago Ave.
Terence T. Quirk, E.M., Ph.D., Instructor in Geology 1603 4th St. S. E.
William H. Richards, Instructor in Carpentry 1423 W. 27th St.
Frank B. Rowley, B.S., M.E., Instructor in Drawing 217 Beacon St. S. E.
Edward H. Sirich, Instructor in Romance Languages 321 14th Ave. S. E.
Woldemar M. Sternberg, B.S.Chem., Instructor in Chemistry 3345 University Ave. S. E.
Sterling Temple, M.A., Instructor in Chemistry 1758 Blair St., St. Paul
Richard Wischkaemper, M.A., Instructor in German 979 14th Ave. S. E.
Arnold Kirkpatrick, Ph.B., Assistant in Chemistry 1703 Taylor Ave., St. Paul
Thomas M. Broderick, Assistant in Geology 3204 Portland Ave.
William L. Uglow, Ph.D., Assistant in Geology 1609 4th St. S. E.

GENERAL INFORMATION

The School of Mines was established by the Board of Regents in 1888, upon recommendation of the General Faculty of the University. The buildings and laboratories of the School are located on the main campus of the University. The mining districts of Minnesota are within a few hours, by rail, from Minneapolis. The heartiest coöperation exists between the various mine managements and the School, so that the mining properties are at all times open to parties from the school for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts. Students in the School of Mines have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

The School of Mines occupies the new building provided by the Legislature of 1913. In the basement are the assay and electro-metallurgical laboratories, together with machinery room, instrument room, balance room, furnace rooms, and necessary storerooms. On the first floor are the administrative offices, offices and lecture rooms of the departments of Metallurgy and Mine Plant and Mechanics. On the second floor are the offices, lecture rooms and drafting rooms of the department of Mining, the ore dressing laboratory, and the library of the school. On the third floor are the offices, laboratories, and lecture rooms of the department of Metallography, junior drafting room, photographic dark rooms, blue printing room, and offices and computing rooms for the branch of the Experiment Station serving the Tax Commission.

DEGREES

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M. (Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four or five years, and vice versa, provided such candidate completes an additional year's work at the School and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and the Mechanic Arts, and in the School of Analytical and Applied Chemistry, who contemplate taking a degree in this School after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thoro courses in mechanics, mathematics, surveying, physics, chemistry, and the necessary theory and practice of structural, mechanical and electrical engineering.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine if it has value for treatment. (d) *Mining Engineering*—to furnish material for treatment. (e) *Ore Testing*—to determine best methods of treatment. (f) *Ore Dressing*—furnishing products for metallurgical treatment. (g) *Metallurgy*—smelting and refining ores and ore dressing products; reduction to metals.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the state, to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the Tax Commission and to do such other work along the lines above outlined as may be requested by other state departments. Coöperation has been effected with the Minnesota Geological Survey and the School of Chemistry.

The Experiment Station is prepared to assist citizens interested in these lines of work; to assay specimens of ore, rocks, clays, and minerals found within the state free of charge.

In submitting samples the sender must state the exact location where each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the office of the Station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, The University of Minnesota, Minneapolis, Minnesota.

LIBRARY

The library occupies a well-lighted room, 55 feet by 61 feet, on the second floor of the School of Mines building. The books have been carefully selected and form a working collection of great value, not only to the faculty and students, but also the mining men of the state. Only books relating to mining, metallurgy, metallography, geology and allied subjects are shelved in this library, the general university library as well as the public libraries of Minneapolis and St. Paul serving as reserve collections. The library is especially rich in complete sets of periodicals, transactions, and the reports of state and foreign mining departments. Foreign technical literature is well represented. A card index is kept of all articles of value and interest appearing in the leading periodicals.

ADMISSION

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology) and Metallurgical Engineer may be completed in either four or five years. Students may enter the School of Mines without preparation in Higher Algebra and Solid Geometry. Such students must enter the five-year courses. It is recommended that students who come poorly prepared in Mathematics enter the five-year courses.

Students may be admitted to the School of Mines either by certificate or examination, or both.

ADMISSION BY EXAMINATION

Entrance examinations are offered at the University during registration week, September 19 to 22. Candidates entering by this method must pass examinations in fifteen units so chosen as to satisfy the requirements outlined below. Certificates from the College Entrance Examination Board and from the High School Board are accepted in lieu of examinations in the subjects they represent. Those desiring to take examinations should notify the Registrar of the University in writing not later than August 31.

ADMISSION BY CERTIFICATE

Graduates of the following courses, provided their preparation satisfies the requirements outlined below, may be admitted.

1. Any four-year course of a Minnesota state high school or other accredited school in the state.

2. A four-year course of schools in any other state accredited to the state university of that state.

3. The Advanced Latin and Advanced English courses of the Minnesota state normal schools.

The applicant for admission should request the principal or superintendent to forward to the Registrar of the University a complete tran-

script of his high-school or preparatory-school record showing the number of weeks and hours per week spent upon each study, with the grades entered as *passed, passed with credit,* or *passed with honor.* Credential blanks prepared by the University must be used; these blanks may be secured upon application to the Registrar. Upon receipt of the credentials at the University the Registrar will notify the applicant with regard to his admission.

ENTRANCE REQUIREMENTS

FIVE-YEAR COURSES

English, three units; Elementary Algebra and Plane Geometry, one unit each; ten additional units, of which not more than four may be in Group F.

FOUR-YEAR COURSES

Same as five-year courses with the addition of one-half unit each of Higher Algebra and Solid Geometry. It is recommended that students who enter these courses review Higher Algebra and Solid Geometry. Those unable to carry freshman mathematics satisfactorily will be required to re-register in the five-year course.

LIST OF ENTRANCE SUBJECTS

The term *unit* means not less than five recitations of forty minutes each per week for a period of thirty-six weeks. In manual subjects and kindred courses, it means the equivalent of ten recitation periods per week for thirty-six weeks.

Group A. English. Four units.

Group B. Languages. Latin, Greek, German, French, Spanish, Scandinavian, one to four units each.

Group C. History and Social Sciences. Ancient and Modern History, one unit each; English and Senior American History, one-half unit each; American Government, Economics, Economic History of England, and Economic History of the United States, one-half unit each; Commercial Geography, and History of Commerce, one-half or one unit each.

Group D. Mathematics. Elementary Algebra and Plane Geometry, one unit each; Higher Algebra, Solid Geometry, and Trigonometry, one-half unit each.

Group E. Natural Sciences. Physics and Chemistry, one unit each; Botany and Zoology, one-half or one unit each; Physiology, Astronomy, Geology, and Physiography, one-half unit each.

Group F. Vocational Subjects. Business Law and Business Arithmetic, one-half unit each; Elementary and Advanced Bookkeeping, one

unit each; Stenography and Typewriting, one or two units. Freehand Drawing, Mechanical Drawing, and Shopwork, one or two units each. Agriculture, one to four units. Normal Training subjects, one to three units, provided the applicant has had one year of subsequent teaching experience.

DESCRIPTION OF SUBJECTS ACCEPTED FOR ADMISSION

A description of the subjects accepted for admission to the University will be found in the Bulletin of General Information, which will be sent to any address upon application to the Registrar, The University of Minnesota, Minneapolis.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

ADMISSION TO ADVANCED STANDING

This University accepts records from all reputable colleges and universities for credit to advanced standing. Such records are accepted as far as they are equivalent to the work done in this institution. In bringing records from other institutions, the certificate must be upon the official blank of the institution granting the certificate and should show:

(a) The subject studied; if a language, the books read, etc.
(b) The number of weeks and hours per week spent upon each subject.
(c) Ground covered in laboratory work in case of laboratory subjects.
(d) The result. The exact grades should be stated, accompanied by an explanation of the marking system employed.

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee of the School of Mines.

EXPENSES

One half of the Annual Incidental Fee of $55, which includes all laboratory charges, is payable at the opening of each semester. Cards entitling the student to admission to classes will not be issued until the fees have been paid. Books and supplies for each year of the course cost approximately $25. Field-work expense during the sophomore year is estimated at $150 and for the junior year at $225.

DEPOSIT FEE

At the beginning of each year, in addition to the first semester incidental fee, a deposit fee of five dollars is required of every student to cover the following items:

Change of Registration..... $2.50
Examination for removal of condition at set time...$1.00 per subject
Rental of post-office box, University post-office (required of all)..... $.50 per year
Locker rental, locker key deposit.....$.50 to $1.00 per year
Laboratory breakages, or damage to University property.
Penalties for late registration or late payment of fees.

A penalty fee of one dollar ($1) must be paid by all students who register or pay fees after the prescribed time. (See calendar, page 3.) After the day previous to that on which classes begin, the penalty for delay increases at the rate of twenty-five cents a day.

The unused balance of the deposit fee will be returned at the end of each year. If, at any time during the college year, the amount of charges against a student exceed the amount of the deposit, a second fee of five dollars ($5) will be required.

SPECIAL FEES

The following special items may be included in the expenses of a student:

Minnesota Union membership, required.....$1 per semester
Special examination for removal of condition, at other than the set time 5.00
Examination on subject taken out of class..... 5.00
No fee for such examinations on first entering the University, if taken within the first six weeks.
Military uniform, required of all freshmen and first-year students 15.00
Gymnasium suit 5.00

THE ELLIOT SCHOLARSHIP LOAN FUND

To fulfill the wish of the late Dr. A. F. Elliot to aid young men who find their efforts to obtain a practical education embarrassed through lack of means, the sum of $5,000 was placed in the hands of the Board of Regents as a scholarship fund. The income from this fund is loaned students in the School of Mines on the following conditions: the financial needs of the applicant, his scholarship, moral character, enthusiasm shown in his work, and promise of usefulness in his profession. When money is available, it may be loaned to pay the expenses of worthy students during sickness. The loans are to be repaid, without interest, at the earliest convenience of the recipients.

GRADUATION

Students completing courses of study to the satisfaction of the Faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in

all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the Faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations held at the end of the second semester. Irregular attendance will debar a student from entering all final examinations.

THESIS

The thesis work is intended to bring in review and connect the work in Mining and Metallurgy, Geology and Mineralogy, Mechanical and Electrical Engineering, Mathematics and Mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of Field Work at the School of Mines, Tuesday, September 19, 1916, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the School.

SPECIAL NOTES

Students failing to receive a semester mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his average in all subjects and present himself for supplementary examinations, according to the program given on page 4.

Failure of the Registrar to notify a student of deficiencies will not be accepted as a reason for neglecting to report for necessary supplementary examinations. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

Students failing to receive a semester mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The Faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination at the end of the first or second semester will be given zero on the examinations.

Students whose absences in either semester exceed four weeks in the aggregate are not permitted to take examinations without special permission of the Faculty.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

During the academic year students will be held responsible for the receipt of official communications sent to them through the University post-office. During the summer vacation they will be held responsible for the receipt of such communications sent to the home address given on registration blank for the preceding academic year, unless forma notification of their correct address is filed with the Registrar and the Dean.

COURSES OF STUDY

UNIFORM CURRICULUM TO END OF SOPHOMORE YEAR

The courses leading to the degrees of Engineer of Mines, Engineer of Mines in Geology, and Metallurgical Engineer, are uniform for the first three years of the five-year courses and for the first two years of the four-year courses.

Five-Year Courses

FIRST YEAR

First Semester

Chemistry 5*, General and Analytical, 5†
Mathematics 1, Computation and Mensuration, 4
Mathematics 3, Mine Accounting, 6
Mechanical Engineering 1, Shop Work, 6
Mineralogy 23, Elements of Mineralogy, 8
Military Drill

Second Semester

Chemistry 6, General and Analytical 7, Chem. 5
Mathematics 2, Algebra, 4
Mechanical Engineering 1, Shop Work, 6
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23
Military Drill

FRESHMAN YEAR

First Semester

Chemistry 11, Quantitative Analysis, 7, Chem. 5, 6
Drawing 11, Engineering Drawing, 10
Geology 105, Elements of Rock Study, 4, Mineral. 24
Mathematics 5, Algebra and Trigonometry, 6, Math. 1, 2
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Military Drill

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*Odd numbers indicate first-semester courses; even numbers, second-semester courses. A combination of the two (e.g., 5-6) indicates courses continuing through the year. In the case of courses repeated the second semester, the suffix *a* indicates first semester; the suffix *b*, second semester.

†Figure following the descriptive name of a course indicates number of hours a week. Course names following indicate prerequisite courses.

Second Semester

Chemistry 12, Quantitative Analysis, 7, Chem. 11
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Geology 1b, General Geology, 3, Mineral. 24
Geology 106, Petrology, 4, Geol. 105
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Military Drill

SOPHOMORE YEAR

First Semester

Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Mathematics 7, Calculus, 5, Math. 6
Geology 73, Historical and Economic Geology, 3, Geol. 106
Metallurgy 105, Base Metals, 4, Met. 4
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1

Second Semester

Drawing 14, Drafting, 4, Draw. 13
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Field Work. Months of May, June, July and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geol. 1b, 105, beginning about June 15
Underground Mining Work, beginning about July 1

Four-Year Courses

FRESHMAN YEAR

First Semester

Chemistry 5, General and Analytical, 5
Drawing 11, Engineering Drawing, 10
Mathematics 5, Algebra and Trigonometry, 6
Mineralogy 23, Elements of Mineralogy, 8
Military Drill

Second Semester

Chemistry 6, General and Analytical, 7, Chem. 5
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23
Military Drill

SOPHOMORE YEAR

First Semester

Chemistry 11, Quantitative Analysis, 7, Chem. 5, 6
Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Geology 105, Elements of Rock Study, 4, Mineral. 24
Mathematics 7, Calculus, 5, Math. 6
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1
Military Drill

Second Semester

Chemistry 12, Quantitative Analysis, 7, Chem. 101
Drawing 14, Drafting, 4, Draw. 13
Geology 1b, General Geology, 3, Mineral. 24
Geology 106, Petrology, 4, Geol. 105
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Military Drill
Field Work. Months of May, June, July and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geol. 1b, 105, beginning about June 15
Underground Mining Work, beginning about July 1

COURSES IN MINING ENGINEERING

COURSES LEADING TO THE DEGREE OF E.M.

Five-Year Courses

JUNIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 5, Ore Dressing, 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 6, Ore Dressing 4, Met. 5
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering 53, Electric Power, 5, Physics, 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Mechanics 16, Mine Plant Design, 10, Mech. 15
Metallurgy 8, Special Problems, 4, Met. 7
Mining 12, 5, Min. 11
Mining 14, Thesis, 12, Min. 13

Four-Year Courses

JUNIOR YEAR

First Semester

Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 73, Historical and Economic Geology, 3, Geol. 106, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 105, Base Metals, 4, Met. 4
Metallurgy 5, Ore Dressing, 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 6, Ore Dressing 5, Met. 5
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Metallurgy 8, Special Problems, 4, Met. 7
Mechanics 16, Mine Plant Design, 10, Mech. 15
Mining 12, 5, Min. 11
Mining 14, Thesis, 12, Min. 13

COURSES LEADING TO THE DEGREE OF E.M. (GEOLOGY)

JUNIOR YEAR

First Semester

Geology 73, Historical and Economic Geology 3, 106, 1b
Geology 11, Paleontology 3, 1b
German 15 or 17, 3, German 16 for 17
or
French 1 or 3, 3, French 2 for 3
Metallurgy 155, Metallography 4
Mining 9, 5, Min. 6
Elective 6 to 10

Second Semester

Geology 124, Structural and Metamorphic Geology 3, 73
Geology 12, Paleontology 3, 57
German 16 or 18, 3 German 15 or 17
or
French 2 or 4, 3, French 1 or 3
Metallurgy 156, Metallography 4, 155
Mining 10, 5, Min. 9
Mining 4, Mine Mapping 6, Min. 2f
Elective 3
Field work to be arranged

SENIOR YEAR

First Semester

Geology 111, Ore Deposits 4, 73
Geology 151, Advanced General Geology, 3
Geology 113, Laboratory course in Economic Geology, 4, with 111
German 17 or 23, 3, German 16 or 18
or
French 3 or 5, 3, French 2 or 4
Mining 11, 5, Min. 10
Thesis, 2
Elective 3

Second Semester

Geology 112, Problems in Ore Deposits 4, Geol. 111
Geology 152, Advanced General Geology, 3
Geology 144, Construction and Interpretation of Geologic Maps, 3, Geol. 111
Geology 138, Testing of Economic Minerals, 3
German 18 or 24, 3, German 17 or 23
or
French 4 or 6, 3, French 3 or 5
Mining 12, 5, Min. 11
Thesis, 4

DEPARTMENT OF MINING ENGINEERING

The department is well supplied with samples of the smaller mine equipment, models, drawings, photographs, lantern slides, and mine maps. The lectures treat of prospecting, development, support of excavations, mining methods, mine administration, mining law, and the necessary allied subjects. The courses in Mining Engineering extend through the sophomore, junior, and senior years.

MINE SURVEYING

The work in surveying is given in the sophomore year and is designed solely for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi or Vermilion Range. The exact location will be announced in March of each year.

The students will be divided into squads of two to four. Each squad must provide itself with a 6-foot steel tape graduated to hundredths. The duration of the course will be seven weeks (5½ days of 8 hours each constitute a week). Each student will be required to complete satisfactorily the following exercises and surveys:

1. Chaining and taping
2. Compass work
3. Adjustment and use of wye and dumpy levels
4. Adjustment of mining transit
5. Reading angles
6. Traverse with transit and steel tape
7. Azimuth traverse with stadia
8. Determination of meridian, latitude, and time by solar and stellar observations
9. Survey of mining claim according to the regulations of the U. S. Government
10. Measurement of earthwork
11. Laying out railroad tangents, curves, and crossings
12. Exercises in plane table work and geological surveying
13. The survey of a mine

A full equipment of surveying instruments of the latest and best makes is furnished to each squad for this work.

This is followed by a course in Mine Mapping during the second semester of junior year.

Students who furnish satisfactory evidence of proficiency in this work may be given credit therefor. The department, however, reserves the right in any case to require such students to take a theoretical or a practical examination or both.

FIELD WORK IN MINING

Sophomore Year

After the close of the field work in Geology (last two weeks in June), members of the sophomore class are required to engage for six weeks in underground mining work on the Minnesota or Michigan iron ranges, for which they may receive wages.

Junior Year

Upon termination of the junior field work in Metallurgy (about May 15), the members of the junior class, who are candidates for the degree of Engineer of Mines, are required to devote two weeks to the study of mine plant and mine operation under the direction of the department. This work will be given in one of the leading western metal mining districts, exact location to be announced in April of each year. Thereafter, during the months of June, July, and August, the student is required to spend at least six weeks in actual underground mining work in the West, for which he may receive wages. The department will render all possible assistance in locating students in districts of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must in person submit this diary to the department on the date of the reopening of field work. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 19, 1916. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering Field Work in Mining and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned: Metallurgy, September 19-26, inclusive; Mining and Mine Plant, September 27–October 9.

On October 9 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 9. These reports shall become the property of the School.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reasons, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

COURSES IN METALLURGY

COURSES LEADING TO THE DEGREE OF MET. E.

Five-Year Courses

JUNIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 5, Ore Dressing, 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 6, Ore Dressing 4, Met. 5
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Metallurgy 11, Special Problems, 8, Met. 106, Min. 8
Metallurgy 109, Electrometallurgy, 3, Met. 106

Second Semester

Chemistry 144, Electrochemistry, 5, Chem. 102
Chemistry 24, Iron and Steel Analysis, 7, Chem. 12
Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Mechanics 18, Mill and Smelter Design, 10, Mech. 15
Metallurgy 152, Metallography, 6, Met. 106
Metallurgy 8, Special Problems, 4, Met. 7
Metallurgy 14, Thesis, 10, Met. 11

Four-Year Courses

JUNIOR YEAR

First Semester

Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 73, Historical and Economic Geology, 3, Geol. 105, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 105, Base Metals, 4, Met. 4
Metallurgy 5, Ore Dressing, 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 5, Ore Dressing 4, Met. 5
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Smelter Work, beginning about June 1

SENIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Metallurgy 11, Special Problems, 8, Met. 106, Min. 8
Metallurgy 109, Electrometallurgy, 3, Met. 106

Second Semester

Chemistry 144, Electrochemistry, 5, Chem. 102
Chemistry 24, Iron and Steel Analysis, 7, Chem. 12
Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Mechanics 18, Mill and Smelter Design, 10, Mech. 15
Metallurgy 152, Metallography, 6, Met. 106
Metallurgy 8, Special Problems, 4, Met. 7
Metallurgy 14, Thesis, 10, Met. 11

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in Metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces. fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags are shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their reports in detail. This work is offered to students completing the necessary courses in Mineralogy and Chemistry.

ORE DRESSING

The lectures and recitations in Ore Dressing extend through the junior year, and comprise the detailed sutdy of ore dressing and concentrating machinery, together with the study of typical combinations of dressing machines as found in the several mining districts of the United States. In connection with the theoretic alwork, the ore dressing laboratory and testing plant of the School is utilized for practical illustrations.

ORE TESTING

The lectures treat of the use and purposes of all the machinery connected with the subject, supplemented by detailed drawings. There are complete testing works, connected with the department where the student may see the working of, and handle for himself crushers, rolls, and concentrating machinery, as well as sizing apparatus and hydraulic separators. Sufficiently large amounts of ore are given to make the necessary tests upon the different machines and the students report the best method of treatment. The courses run through senior year and are required of students both in Mining and Metallurgy.

The ore-testing works meet educational, as well as commercial, needs.

Educational.—The ore-testing plant acquaints the student with the construction and manipulation of the principal typical machines used in the leading ore-dressing establishments of the country. It is here that students in Mining and Metallurgical Engineering get the requisite practical experience. They handle all machines and operate on sufficiently large amounts of material to determine the methods best suited to a given ore to extract the largest amount of metal with the least possible loss.

Commercial.—Ore-testing works are an important factor in mining and metallurgical projects. The commercial object is to determine the best method of treating a given ore so as to yield the largest percentage of the metal it contains at the least possible cost. Samples varying from 500 pounds to car-load lots can be treated by various methods.

As the funds appropriated for the erection of such a plant were sufficient to purchase only the necessary machinery, the business men of Minneapolis generously provided a suitable building. This building, 94 by 66 feet, is built of brick and stone.

FIELD WORK IN METALLURGY

At the end of the junior year opportunity is given the student to study metallurgical operations at one or more smelting works. This work will begin about May 1. Not over two weeks' time will be devoted to this work.

Upon termination of the junior field work in Metallurgy and two weeks in Mining (not later than June 1), the members of the junior class who are candidates for the degree of Metallurgical Engineer, are required to spend at least six weeks in practical work in one or more of the smelters of the West, for which they may receive wages. The department will render all possible assistance in locating students in districts of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must, in person, submit this diary to the department on date of reopening of field work. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 19, 1916. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering field work in Metallurgy and Mining must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: Metallurgy, September 19-26, inclusive; Mining and Mine Plant, September 27-October 9.

On October 9 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a type-

written report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 9. These reports shall become the property of the School.

METALLOGRAPHY

Courses in Metallography are offered to seniors who are candidates for the degree of Metallurgical Engineer, students in the Colleges of Science, Literature, and the Arts, Engineering, Chemistry, and the Graduate School.

These courses deal with the microscopic examination of metals, alloys, and ores. The lectures treat of and describe the apparatus used in connection with this subject, the methods of preparing specimens, the physical, chemical, and metallurgical principles involved, and the interpretation of the results of microscopic examination. A collection of specimens, micro-photographs, and lantern slides covering wrought iron, low carbon, structural, rail, and tool steels, brasses, bronzes, and other industrial alloys are available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals, alloys, and ores. The laboratory is equipped with microscopes, electric and portable gas furnaces, and pyrometers of the latest and improved types. A special dark room is available for the preparation of microphotographs.

DEPARTMENTAL STATEMENTS

EXPLANATION OF COURSE NUMBERS

Odd numbers indicate first-semester courses; even numbers, second-semester courses. A combination of the two (e.g., 5-6) indicates courses continuing through the year. The suffixes *a* and *b* apply to one-semester courses offered both semesters, *a* indicating the first semester and *b* the second semester (e.g., 3a,b; 4a,b). The suffix *f* indicates summer field work.

All undergraduate courses are numbered from 1 to 100. All courses open to undergraduates and graduates are numbered from 101 to 200. Strictly graduate courses are numbered from 201 up.

CHEMISTRY

Professors George B. Frankforter, Charles F. Sidener; Instructors Woldemar M. Sternberg, Sterling Temple, Gerhard Dietrichson; Assistant Arnold Kirkpatrick.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
5.	Gen. & Anal. Chemistry...	3	2	All Fr.	..
6.	Gen. & Anal. Chemistry...	1	6	All Fr.	5
11.	Quantitative Analysis.....	1	6	All Soph.	6
12.	Quantitative Analysis.....	1	6	All Soph.	11
24.	Iron & Steel Analysis.....	1	6	Sr. Met. E.	12
25.	Ore & Slag Analysis.....	1	6	Sr. E. M. & Met. E.	12
144.	Electrochemistry	1	4	Sr. Met. E.	12

5-6. General and Analytical Chemistry. An introduction to descriptive, physical, and metallurgical chemistry and qualitative analysis. Frankforter, Temple, and Assistants.

11-12. Quantitative Analysis. A general discussion of quantitative methods, with laboratory work in gravimetric analysis, first semester; followed by a discussion of standard solutions and the necessary stoichiometric calculations with laboratory work in volumetric analysis, second semester. Sidener, Sternberg, and Assistants.

24. Iron and Steel Analysis. Includes technical methods for the determination of the common constituents of iron ores, iron, and steel, with training in rapid work. Sidener, Sternberg.

25. Ore and Slag Analysis. Rapid technical method for the determination of certain constituents in ores and slags. Sidener, Sternberg.

144. Electrochemistry. A discussion of electro-analytical methods and industrial electrochemical processes, and their underlying principles. Dietrichson.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor WILLIAM H. KIRCHNER; Instructors CHARLES H. BLITMAN, ROBERT W. FRENCH, FRANK B. ROWLEY.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11.	Engineering Drawing	..	10	All Fr.	
12.	Engineering Drawing	..	8	All Fr.	11
13.	Descriptive Geometry	2	..	All Soph.	12, Math. 6
14.	Drafting	..	4	All Soph.	13

11. ENGINEERING DRAWING. Sketching, lettering, representation, parallel and radial projection, elements of engineering, representation of details of machines and structures, interpretation of working drawings. KIRCHNER, BLITMAN.

12. ENGINEERING DRAWING. Continuation of Course 11 as outlined above. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Maps and sketches. Brush and pen conventions. ROWLEY, BLITMAN.

13. DESCRIPTIVE GEOMETRY. Projection: central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. KIRCHNER.

14. DRAFTING. Graphics, machine drafting, and structural drafting. Instruction in drafting room methods. FRENCH.

ELECTRICAL ENGINEERING

Professor GEORGE D. SHEPARDSON; Assistant Professor WILLIAM T. RYAN.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
53.	Electric Power	2	2	Sr. E. M. & Met. E.	Physics 3, 4

53. ELECTRIC POWER. Elements of theory and practice of electrical measurements, wiring, dynamos, motors, and electric lighting. RYAN.

EXPERIMENTAL ENGINEERING

Professor WILLIAM H. KAVANAUGH; Assistant Professors CHARLES F. SHOOP, FRANKLIN R. MCMILLAN.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
21.	Steam Laboratory	..	4	Jr. E. M. & Met. E.	With Math. 11
22.	Strength of Materials	..	4	Jr. E. M. & Met. E.	With Math. 10
24.	Experimental Laboratory	..	4	Sr. E. M. & Met. E.	21

21. Steam Laboratory. Exercises in valve setting, indicator practice, calibration of steam gauges, efficiency of screws and hoists. Shoop.

22. Strength of Materials. Laboratory work, investigating the strength and physical qualities of iron, steel, brass, copper, belting, chains, beams, brick, and stone. McMillan.

24. Experimental Laboratory. Hydraulic measurements. Calibration of weirs, nozzles, meters, and other hydraulic apparatus, calorimetry; tests of pumps, engines, and boilers. Kavanaugh.

GEOLOGY AND MINERALOGY

Professor William H. Emmons; Associate Professor Clinton R. Stauffer; Assistant Professor Frank F. Grout; Instructors A. Walfred Johnston, T. T. Quirk; Assistants T. M. Broderick, W. L. Uglow.

COURSES

No.	Title	Lect. or rec. hrs.	Lab hrs.	Required of	Prereq. courses
1b.	General Geology	3	..	All Soph.	24
1f.	Field Work	..	2 wks	All Soph.	1b and 105
11.	Paleontology	3	..	Jr. E. M. (Geol.)	1b
12.	Paleontology	3	..	Jr. E. M. (Geol.)	11
23.	Elements of Mineralogy	4	4	All Fr.	..
24.	Descriptive Mineralogy	2	2	All Fr.	23
73.	Histor. & Econ. Geology	3	..	All Jr.	1b and 105
105.	Elements of Rock Study	..	4	All Soph.	24
106.	Petrology	..	4	All Soph.	105b
111.	Ore Deposits	4	..	Sr. E. M. & E. M. (Geol.)	106
112.	Problems in Ore Deposits	..	4	Sr. E. M. & E. M. (Geol.)	111
113.	Laboratory Course in Econ. Geology	..	4	Sr. E. M. (Geol.)	With 111
124.	Struct. & Metamorph. Geol.	3	..	Jr. E. M. (Geol.)	73 and 105
138.	Testing Econ. Minerals	..	4	Elective	24 and 73
144.	Construction & Interpretation of Geologic Maps	..	4	Elective	73
151.	Advanced General Geology	3	..	Sr. E. M. (Geol.)	73
152.	Advanced General Geology	3	..	Sr. E. M. (Geol.)	151

1b. General Geology. A synoptical treatment of materials of the earth and of geologic processes. Physiographic, dynamic, and structural geology, with a brief introduction to Historical Geology. Johnston.

1f. Field Work. A two-week excursion to the Iron Ranges for practice in field methods, such as tracing contacts, working out structures and constructing and interpreting geologic maps. Johnston and Assistants.

11. Paleontology. A study of fossil forms with special reference to those of geological importance. Stauffer.

12. Paleontology. Faunas and their correlation. A continuation of Course 11. Stauffer.

23. Elements of Mineralogy. The crystal systems; morphological, physical, and chemical character of minerals; occurrence, genesis, and uses of minerals; classifications and description of common minerals. Determinative work in laboratory, blowpipe analysis, sight identification. Grout, Broderick, Uglow.

24. Descriptive Mineralogy. A continuation of Course 23, special attention being given to metalliferous and rock-forming minerals. Laboratory determination and sight identification. The use of the goniometer and microscope. Laboratory work, reference reading, and field excursions. Grout, Broderick, Uglow.

73. Historical and Economic Geology. (a) Historical Geology. The geologic history of North America, with special reference to its syngenetic mineral deposits. (b) Economic Geology. A study of the non-metallic minerals of economic value, and discussions of the geologic guides to prospecting for these deposits. Emmons, Quirk.

105. Elements of Rock Study. The occurrence and genesis of igneous sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. Broderick.

106. Petrology. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and metamorphic rocks. The origin and classification of rocks. Broderick.

111. Ore Deposits. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. Emmons.

112. Problems in Ore Deposits. Field excursions, map work, lectures on field and laboratory methods. Emmons.

113. Laboratory Course in Economic Geology. A study of ores, rocks and geological structure of selected American and foreign mining districts. Correlated reading. Emmons.

124. Structural and Metamorphic Geology. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. Johnston.

138. Testing Economic Minerals. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, oil, building stone, and metallic ores.

144. Construction and Interpretation of Geologic Maps. Hours to be arranged. Methods of geologic examination; problems in construction and interpretation of geologic maps and sections, with special

reference to underground mapping of metalliferous areas; field practice in plane table methods of topographic and geologic mapping. QUIRK.

151. ADVANCED GENERAL GEOLOGY. Geologic processes and their results; development of the North American continent. STAUFFER.

152. ADVANCED GENERAL GEOLOGY. A continuation of Course 151. STAUFFER.

GERMAN

Professor CARL SCHLENKER; Assistant Professors OSCAR C. BURKHARD, Instructors J. THEODORE GEISSENDOERFER, RICHARD WISCHKAEMPER.

COURSES

No.	Title	Lect. or rec. hrs.	Required of	Prereq. courses
15.	Beginning German	3	Jr. E. M. (Geol.)	..
16.	Beginning German	3	Jr. E. M. (Geol.)	15
17.	Scientific Intermediate	3	Jr. or Sr. E. M. (Geol.)	16
18.	Scientific Intermediate	3	Jr. or Sr. E. M. (Geol.)	17
23.	Advanced Scientific	3	Sr. E. M. (Geol.)	18
24.	Advanced Scientific	3	Sr. E. M. (Geol.)	23

15-16. BEGINNING. Pronunciation, grammar, conversation, and composition; selected reading in easy prose and verse. BURKHARD.

17-18. SCIENTIFIC INTERMEDIATE. This course is arranged to meet the needs of students in the School of Mines. Text: Merckel's *Bilder aus der Ingenieurtechnik*. BURKHARD.

23-24. ADVANCED SCIENTIFIC READING. Reading of monographs and periodicals. GEISSENDOERFER, WISCHKAEMPER.

MECHANICAL ENGINEERING

Professor JOHN J. FLATHER; Assistant Professor S. CARL SHIPLEY; Instructors EDWARD QUIGLEY, WILLIAM H. RICHARDS.

COURSES

No.	Title	Lab. hrs.	Required of	Prereq. courses
1a.	Pattern Making	6 (9 wks)	1st-yr. E. M. & Met. E.	..
1b.	Foundry	6 (9 wks)	1st-yr. E. M. & Met. E.	..
1c.	Forge	6 (9 wks)	1st-yr. E. M. & Met. E.	..
1d.	Machine & Bench work	6 (9 wks)	1st-yr. E. M. & Met. E.	..

1a. PATTERN MAKING. Use of tools, lathe and bench work, making of timber joints, core boxes and flasks. RICHARDS.

1b. FOUNDRY. Molding, core making, mixing and casting metals. QUIGLEY.

1c. FORGE. Use of tools, forging, welding, tool dressing and tempering. QUIGLEY.

1d. Machine and Bench Work. Use of tools and elementary machine operations. Shipley.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Assistant Professor Samuel L. Hoyt; Instructor Ervin W. McCullough.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
2.	Assaying	4	8	All Fr.	Chem. 5, Mineral. 23
3.	Gen. Met. & Iron and Steel	3	..	Soph. E. M. & Met. E.	2, Chem. 6
4.	Wrought Iron & Steel	3	..	Soph. E. M. & Met. E.	3
5.	Ore Dressing	4	..	All Jr.	..
6.	Ore Dressing	4	..	All Jr.	..
6f.	Field Work in Metallurgy	..	10 dys	Jr. E. M. & Met. E.	Satisfactory completion of Jr. year
7.	Ore Testing	2	8	Sr. E. M. & Met. E.	106, 5
8.	Special Problems in Ore Testing	..	4	Sr. E. M. & Met. E.	7
11.	Special Problems in Met.	..	8	Sr. Met. E.	106, 5
14.	Thesis and Specifications	..	10	Sr. Met. E.	11
105.	Met. of Base Metals	4	..	Jr. E. M. & Met. E.	4
106.	Met. of Precious Metals	4	..	Jr. E. M. & Met. E.	105
109.	Electrometallurgy	3	..	Sr. Met. E.	106
152.	Metallography	2	4	Sr. Met. E.	106
153.	Metallography	3	4	Elective	Chem. 12, Phys. 1 and 2
154.	Metallography	3	4	Elective	153
155.	Metallog. for Geologists	2	2	Elective	Geol. 4, 5 & 18
156.	Metallog. for Geologists	2	2	Elective	155
157.	Metallog. for Engineers	2	4	Elective	Mech. Eng. 3 and 4
160.	Metallog. for Chemists	2	2	Elective	Chem. 12, Phys. 1 and 2
162.	Ad. Metallog. for Eng.	2	4	Elective	157
163.	Dental Metallog.	3	..	Elective	..
201.	Ad. Metallog.	To be ar.		Elective	154
202.	Ad. Metallog.	To be ar.		Elective	201

2. Assaying. Determination of values of ores, metallurgical products, and bullion. Appleby and Assistants.

3. General Metallurgy and Metallurgy of Iron. Including the subjects of combustion, fuels, refractory materials and furnaces. Lectures and recitations on metallurgy of iron. Christianson.

4. Metallurgy of Wrought Iron and Steel. Consideration of the principles of manufacture, details of plant construction, and chemical and physical phenomena. Christianson.

5-6. Ore Dressing. Examination of ores, crushing, sizing classification, and methods of mechanical separation. McCullough.

6f. Field Work in Metallurgy. Study of metallurgical operations at smelters and mills. Detailed report is required covering plants visited. Christianson, Pease.

7. Ore Testing. Determinations of methods of ore treatment, stamping, concentration, cyanidation, roasting, and amalgamation. Christianson and Assistants.

8. Special Problems in Ore Testing. Continuation of Course 7. Pease and Assistants.

11. Special Problems in Metallurgy. Research work preparatory to thesis. Appleby and Assistants.

14. Thesis and Specifications. Detailed investigations of ore treatment, with report including designs and specifications for suitable plants. Appleby, Comstock, and Assistants.

105. Metallurgy of the Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining methods. Pease.

106. Metallurgy of the Precious Metals. Gold, silver, and platinum. Methods and principles of cyanidation, chlorination, amalgamation, and lixiviation as applied to the treatment of the above. Pease.

109. Electrometallurgy. A study of the reduction of ores, refining of metals, and production of metals by electrolytic deposition; and the use of the electric furnace for smelting of ores, refining metals, and the manufacture of refractory alloys. Christianson.

152. Metallography. A study of the microstructure of metals and alloys as affected by heat and industrial treatments, together with the influence of changes of structure on their properties. Special attention is given to siderurgic products. Hoyt.

153-154. Metallography. Theory of metallic alloys. Metallographic technique. Properties of metals and alloys. Metallography of iron and steel and commercial alloys. Technical metallography. Hoyt.

155-156. Metallography Applied to the Study of Geology. Physico-chemical principles and their application to the study of the genesis of rocks and ore bodies. Microscopical examination and synthetic preparation of opaque minerals. Hoyt.

157. Metallography for Engineering Students. Metallurgy of iron and steel. Microscopic and thermal analysis of steel and cast iron; heat and mechanical treatment. The properties of iron and steel as affected by composition and treatment. Laboratory work. Hoyt.

100. Metallography for Chemical Students. The preparation of metallic alloys; their microscopical and thermal analysis. Steel and other commercial alloys with particular reference to chemical metallurgy. Corrosion of steel and non-ferrous alloys. Metallography applied to analytical chemistry. Hoyt.

102. Advanced Metallography for Engineering Students. Metallography applied to engineering practice; machine design, structural engineering, electrical engineering. Engineering specifications involving the use of metals and alloys. Hoyt.

163. Dental Metallography. Study of the dental alloys from the standpoint of metallography. Hoyt.

201-202. Advanced Metallography. Technical and scientific research. The study of steel rails, automobile and locomotive parts, tool steels etc. Special problems in metallography with outside reading. Seminar work on the recent advances in metallography. Hoyt.

MINE PLANT AND MECHANICS

Professor Elting H. Comstock; Assistant Professor Edwin M. Lambert; Instructor Edward W. Davis.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Computation & Mensuration	3	..	All 1st-yr. students	..
3.	Mine Accounting	..	6	All 1st-yr. students	..
4.	Algebra	4	..	All 1st-yr. students	..
5.	Algebra & Trigonometry	6	..	All Fr.	1 & 2
6.	Spherical Trig. & Anal. Geom.	6	..	All Fr.	5
7.	Calculus	5	..	All Soph.	6
8.	Calculus	3	..	All Soph.	7
9.	Mechanics	5	..	All Jr.	8
10.	Mechanics	6	..	All Jr.	9
11.	Mine Plant	5	..	Jr. E. M. & Met. E.	8
12.	Mine Plant	6	..	Jr. E. M. & Met. E.	11
13.	Hydraulics & Water-Power	5	..	All Sr.	10
15.	Engineering Construction.	1	4	Sr. E. M. & Met. E.	10
16.	Mine Plant Design	..	10	Sr. E. M.	15
18.	Mill and Smelter Design	..	6	Sr. Met. E.	15

1. Computation and Mensuration. Demonstrations of most important theorems of solid geometry. Volumes, approximate volumes, prismoidal formula, etc. Approximate computation, graphs, and graphical computation, logarithms and logarithmic computation, areas and approximations of areas, use of slide rule. Davis.

3. Elementary Mine Accounting. Elementary accounting in general; applications to mine accounts; primary records, labor, supply, mine and mill products, and fund sheets; secondary records, invoice, labor and supply, mine and mill cost sheets, trial balance. Lambert.

4. Algebra. Equations with one, two, or more unknown quantities, inequalities, involution and evolution, theory of exponents, surds, quadratic equations both numerical and literal, equations with one or more unknown quantities that can be solved by means of quadratic equations, progressions. Davis.

5. Algebra and Trigonometry. Functions and functional notation, factor and remainder theorems, factors and values of functions, determinants, development of functions, theory of equations, permutations and combinations; trigonometric ratios, right triangles, general definitions of trigonometric functions, analytic relations, addition formulas, trigonometric equations, and oblique triangles. Davis.

6. Spherical Trigonometry and Analytical Geometry. General properties and solution of spherical triangles; systems of coördinates, loci, equations and properties of the straight line, transformation of coördinates, equations and properties of conics, general equations of the second degree, higher plane curves, space coördinates, point, plane, straight line, quadric surfaces. Davis.

7. Calculus. Nature of differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, indeterminate forms, partial derivatives, change of variable. Lambert.

8. Calculus. Elementary integration, undetermined coefficients, rational fractions, rationalization, formulas of reduction, hyperbolic functions, some differential equations of mechanics. Lambert.

9. Mechanics. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy; elementary mechanics of materials. Lambert.

10. Mechanics. Mechanical and elastic properties of materials of construction; beams, shafts, columns, reinforced concrete, hollow cylinders and spheres, rollers, plates; theory of internal stress. Lambert.

11-12. Mine Plant. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. Comstock.

13. Hydraulics and Water-Power. Laws of the equilibrium, pressure, and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, speed control, power-house equipment, transmission. Comstock.

15. Engineering Construction. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures, design of mining structures. Lambert.

16. Mine Plant Design. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. Comstock.

18. Mill and Smelter Design. A study of the construction and mechanical equipment of mills and smelters in connection with thesis work. Comstock.

MINING ENGINEERING

Professor Edward P. McCarty; Instructor John F. Murphy.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Mine Surveying	3	..	All Soph.	Math. 6
2.	Mine Surveying	3	..	All Soph.	1
2f.	Field Work	..	7 wks	All Soph.	2
4.	Mine Mapping	..	6	All Jr.	2f
6.	Mining	1	..	All Soph.	..
9.	Mining	5	..	All Jr.	6
10.	Mining	5	..	All Jr.	9
10f.	Practical Mining	..	2 wks	All Jr.	Satisfactory completion of Jr. year
11.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	10
12.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	11
13.	Thesis	..	2	Sr. E. M.	10f
14.	Thesis	..	8	Sr. E. M.	13

1, 2. Mine Surveying. Computation, platting, and problems with special reference to mine surveying. Murphy.

2f. Field Work. Practice in general surveying during the month of May. Practice in underground surveying during the first two weeks of June. This work is given on the Iron Ranges. McCarty, Murphy.

4. Mine Mapping. Mine mapping in accordance with prevalent practice in the western mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. Murphy.

6. Mining. Examination and testing, and use of explosives. Murphy.

9. Mining. Occurrence of ore bodies, prospecting, churn and diamond drilling, drilling, blasting, excavation, surface transportation, tunneling and drifting. McCarty.

10. Mining. Shaft-sinking, support of underground excavations, hoisting, drainage, ventilation, underground transportation. McCarty.

10f. Practical Mining. Study of mining operations. Mine plant and equipment and practical mining work; a mine to be selected by department during months of May, June, July, and August. McCarty Comstock, and Assistants.

11. MINING. Open pit, quarrying, underground methods, coal mining. mining alluvial deposits. McCARTY.

12. MINING. Mine management, mining law, economics of mining, mine examination, mine sanitation and hygiene. McCARTY.

13, 14. THESIS. Conference. Design and specifications of mining details required in thesis study. McCARTY and Assistants.

PHYSICS

Professors HENRY A. ERIKSON, ANTHONY ZELENY; Instructor E. O. DIETERICH.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	General Physics	3	..	All Soph.	Math. 6
2.	General Physics	3	..	All Soph.	1
3.	General Lab. Practice	..	2	All Soph.	With 1
4.	General Lab. Practice	..	2	All Soph.	With 2

1. GENERAL PHYSICS. Mechanics of solids and fluids, sound and heat. Treatment experimental rather than mathematical; the fundamental principles. ERIKSON. DIETERICH.

2. GENERAL PHYSICS. Light, electricity, and magnetism. Treatment experimental; the fundamental principles, including those of radioactivity, ionization, X-radiation, and the electrical constitution of matter. ERIKSON, DIETERICH.

3. GENERAL LABORATORY PRACTICE. Physical measurements in the mechanics of solids and fluids, and in heat and sound, giving the student a knowledge of experimental methods, and an intimate acquaintance with the fundamental facts of the subject. DIETERICH.

4. GENERAL LABORATORY PRACTICE. Physical measurements in light, electricity, and magnetism. DIETERICH.

ROMANCE LANGUAGES

Professor EVERETT WARD OLMSTED; Assistant Professor JULES T. FRELIN; Instructor E. H. SIRICH.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
1.	Beginning French	3	Jr. E. M. (Geol.)	..
2.	Beginning French	3	Jr. E. M. (Geol.)	1
3.	Intermediate French	3	Jr. or Sr. E. M. (Geol.)	2
4.	Intermediate French	3	Jr. or Sr. E. M. (Geol.)	3
5.	Survey French Lit.	3	Sr. E. M. (Geol.)	4
6.	Survey French Lit.	3	Sr. E. M. (Geol.)	5

1-2. BEGINNING FRENCH. Stress on accurate pronunciation, reading, reading vocabulary, and the essentials of grammar. Daily oral and written exercises (dictation and reproduction in French). FRELIN, SIRICH.

3-4. Intermediate. French grammar, composition, and reading; increased use of French in the classroom. Selections from modern prose and poetry. Frelin.

5-6. General Survey of French Literature. Lectures, recitations, and assigned readings. Designed to cover the whole period in historical outline. Selections from representative authors. Olmsted.

STUDENTS

SENIORS—11

Abrahamson, Hjalmar, Wadena
Aronson, Sam, St. Paul
Buresch, Charles E., Lakefield
Craig, John J., Minneapolis
Davies, Fred A., Minneapolis
Dovre, Adolph, Sleepy Eye
Krogh, Alvin T., Minneapolis
Lee, Oscar, St. Paul
McDermid, Archie, Duluth
McHardy, Roy H., Minneapolis
Nord, Harry H., Ashland, Wis.

JUNIORS—15

Anderson, Edwin H., Oakes, N. D.
Cassilly, Thomas E., St. Paul
Coryell, Lewis S., Osceola, Wis.
Dennis, Richard C., Ashland, Wis.
Dopp, Lawrence, Ashland, Wis.
Elson, William H., St. Paul
Ernster, Omer F., Brainerd
Fearing, Edward J., Little Falls, Minn.
Kwong, Yih-Kum, Shanghai, China
Levorsen, A. Irving, Fergus Falls
Peterson, Paul A., St. Paul
Shattuck, Warner A., Bisbee, Ariz.
Sweetman, Edwin A., Aitkin
Wallace, Carleton S., Minneapolis
Woodruff, John J., Minneapolis

SOPHOMORES—26

Ainsworth, Robert E., Minneapolis
Allard, Raymond, St. Paul
Armstrong, Harold K., Minneapolis
Bailey, A. Kittredge, Minneapolis
Clark, Fred E., Minneapolis
Copeland, William A., St. Paul
Cowin, Percy G., Minneapolis
Dane, Carleton M., St. Paul
Dowdell, Ralph L., St. Paul
Foley, Lyndon L., Minneapolis
Frank, Harry, Minneapolis
Gannett, Roger W., Minneapolis
Hicks, John, St. Paul
Hsieh, Chung, Kirin, China
Hubbard, William E., Duluth
Ingersoll, Guy E., Hibbing
Jerrard, Walter L., St. Cloud
Johnson, Russell V., Lanesboro
Lee, Liang, Ningyuen, China
McGilvra, Donald, Minneapolis
Miao, Yun Tai, Yunnanfu, China
Moga, John A., St. Paul
Quinn, Howard E., Melrose
Sinclair, Gilbert, Minneapolis
Stickney, Robert A., Englewood, N. J.
Sullivan, Daniel C., Stillwater

FRESHMEN—17

Abramson, Jake, Minneapolis
Barr, Joseph C., Riverton
Calhoun, Robert, Minneapolis
Donaghue, Abner J., Minneapolis
Flom, Frank, Minneapolis
Frank, Elden J., Duluth
Frellsen, Sidney A., Minneapolis
Gandrud, Bennie W., Glenwood
Goldberg, Bert, St. Paul
Goldberg, Samuel B., St. Paul
Hosted, Joseph, Duluth
Hoving, George E., Fergus Falls
Moriarty, Howard M., Minneapolis
Mellem, Walter R., St. Paul
Mullowney, Marion F., Minneapolis
Newton, Valentine H., New York
Wadsworth, Lawrence H., Minneapolis

FIRST YEAR—7

Berlin, Hale D., Wimbledon, N. D.
Case, Carlos C., Minneapolis
Johnsen, Trygve, St. Paul
Johnston, Kenneth A., St. Paul
Rydlun, Edwyn, Minneapolis
Salet, Harry N., St. Paul
Thoeni, Victor T., Wykoff, Minn.

The Bulletin *of the* University *of* Minnesota

The School of Mines
Announcement for the Year
1917-1918

Catalog Series No. 10
Vol. XX No. 26 July 16 1917

Entered at the post-office
in Minneapolis as second-class matter
Minneapolis, Minnesota

1917

JULY

Su	Mo	Tu	W	Th	Fr	Sa
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DECEMBER

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UNIVERSITY CALENDAR

1917-1918

1917			
September	26	Wednesday	Registration closes for all students
September	26	Week	Fees payable for all students
October	3		
October	1	Monday	First semester evening extension classes begin
October	2-9	Week	Examinations for removal of conditions (except for Colleges of Agriculture and Forestry), and entrance examinations
October	10	Wednesday	First semester begins
October	15	Monday	Agricultural College, farm experience examinations
October	18	Thursday	School of Agriculture, first term begins
October	29	Monday	Senate meeting, 4:00 p.m.
November	5	Monday	Dairy School opens
November	28	Wednesday	Thanksgiving recess begins 9:00 p.m.
December	1	Saturday	Dairy School closes
December	3	Monday	Thanksgiving recess ends 8:00 a.m.
December	3-8	Week	Second semester condition examinations, Colleges of Agriculture and Forestry
December	3-8	Week	Short course for ice-cream makers
December	5	Wednesday	Medical School second quarter begins
December	20	Thursday	Senate meeting, 4:00 p.m.
December	21	Friday	School of Agriculture, first term closes
December	21	Friday	Christmas vacation begins 9:00 p.m.
1918			
December	31	Week	Farmers' and Home Makers' Week
January	5		Short Course
January	2	Wednesday	Christmas vacation ends 8:00 a.m.
January	2	Wednesday	School of Embalming begins, eight weeks' session
January	8	Tuesday	School of Agriculture, second term begins
January	25	Friday	First semester evening extension classes close
February	4	Monday	Second semester registration closes
February	4	Monday	Second semester evening extension classes begin
February	4-9	Week	Merchants' Short Course
February	11	Monday	Final examinations begin
February	11	Monday	Payment of fees for second semester closes

February	12	Tuesday	Lincoln's Birthday; a holiday
February	18	Monday	Second semester begins
February	21	Thursday	Senate meeting, 4:00 p.m.
February	22	Friday	Washington's Birthday; a holiday
March	27	Wednesday	School of Agriculture closes
March	28	Thursday	Easter recess begins 9:00 p.m.
April	1	Monday	Easter recess ends 8:00 a.m.
April	1-6	Week	Boys' and Girls' Week
April	1-6	Week	Condition examinations in certain colleges
April	15	Monday	Medical School fourth quarter begins
April	30	Tuesday	Traction Engineering Short Course begins
May	16	Thursday	Senate meeting, 4:00 p.m.
May	24	Friday	Second semester evening extension classes close
May	30	Thursday	Memorial Day; a holiday
May	31	Friday	Traction Engineering Short Course closes
June	8	Saturday	Final examinations begin 2:00 p.m.
June	15	Saturday	Second semester closes
June	16	Sunday	Baccalaureate service
June	17	Monday	Senior Class Day exercises
June	19	Wednesday	Alumni Day
June	20	Thursday	Forty-sixth Annual Commencement
June	21	Friday	Summer vacation begins
June	24	Monday	Summer Session begins

The University year for 1918-19 will begin Tuesday, September 17. Classes will begin September 25.

Program of Supplementary Examinations

Tuesday	Oct. 2	9-12 a.m.	Mechanics and Mathematics
		2-5 p.m.	Mining Engineering Subjects
Wednesday	Oct. 3	9-12 a.m.	Chemistry
		2-5 p.m.	Drawing and Descriptive Geometry
		2-5 p.m.	Mechanical Engineering Subjects
Thursday	Oct. 4	9-12 a.m.	Metallurgical Subjects
		2-5 p.m.	Physics
Friday	Oct. 5	9-12 a.m.	Electrical Engineering Subjects
		2-5 p.m.	Geology and Mineralogy

THE SCHOOL OF MINES

FACULTY

MARION LEROY BURTON, D.D., Ph.D., LL.D., President
1005 5th St. S. E.

CYRUS NORTHROP, LL.D., President Emeritus 519 10th Ave. S. E.

WILLIAM R. APPLEBY, M.A., Dean and Professor of Metallurgy
928 5th St. S. E.

OSCAR C. BURKHARD, M.A., Assistant Professor of German
719 E. River Road

PETER CHRISTIANSON, B.S., E.M., Professor of Metallurgy
217 Union St. S. E.

ELTING H. COMSTOCK, M.S., Professor of Mine Plant and Mechanics
1416 7th St. S. E.

WILLIAM H. EMMONS, Ph.D., Professor of Mineralogy and Geology
611 11th Ave. S. E.

HENRY A. ERIKSON, Ph.D., Professor of Physics 424 Harvard St. S. E.

JOHN J. FLATHER, Ph.B., M.M.E., Professor of Mechanical Engineering
315 11th Ave. S. E.

GEORGE B. FRANKFORTER, Ph.D., Professor of Chemistry
525 E. River Road

JULES T. FRELIN, B.A., Assistant Professor of Romance Languages
1206 5th St. S. E.

ROBERT W. FRENCH, B.S., Assistant Professor of Drawing
1018 16th Ave. S. E.

FRANK F. GROUT, M.S., Associate Professor of Geology and Mineralogy
617 4th St. S. E.

SAMUEL L. HOYT, E.M., Ph.D., Assistant Professor of Metallography
416 8th Ave. S. E.

A. WALFRED JOHNSTON, M.A., Assistant Professor of Geology
803 University Ave. S. E.

WILLIAM H. KIRCHNER, B.S., Professor of Drawing and Descriptive Geometry 722 10th Ave. S. E.

EDWIN M. LAMBERT, M.E., Assistant Professor of Mine Plant and Mechanics 1086 12th Ave. S. E.

FRANKLIN R. MCMILLAN, C.E., Assistant Professor of Structural Engineering 524 8th Ave. S. E.

JOHN F. MURPHY, Associate Professor of Mining 519 7th Ave. S. E.

EVERETT W. OLMSTED, Ph.D., Professor of Romance Languages
901 5th St. S. E.

LEVI B. PEASE, M.S., Professor of Metallurgy 1070 16th Ave. S. E.

TERENCE T. QUIRKE, E.M., Ph.D., Assistant Professor of Geology
315 11th Ave. S. E.

FRANK B. ROWLEY, Assistant Professor of Experimental Engineering
217 Beacon St. S. E.

William T. Ryan, E.E., Assistant Professor of Electrical Engineering 3228 4th St. S. E.
Carl Schlenker, B.A., Professor of German 514 11th Ave. S. E.
George D. Shepardson, M.A., M.E., D.Sc., Professor of Electrical Engineering 717 E. River Road
S. Carl Shipley, B.S., M.E., Assistant Professor of Machine Construction 1517 E. River Road
Charles F. Shoop, B.S., Assistant Professor of Experimental Engineering 811 Fulton St. S. E.
Charles F. Sidener, B.S., Professor of Chemistry 1320 5th St. S. E.
Clinton R. Stauffer, Ph.D., Associate Professor of Geology 1023 University Ave. S. E.
Sterling Temple, M.A., Assistant Professor of Chemistry 1758 Blair St., St. Paul
Anthony Zeleny, Ph.D., Professor of Physics 613 Fulton St. S. E.
Thomas M. Broderick, Ph.D., Instructor in Geology 3204 Portland Ave.
Anders J. Carlson, Instructor in Mining 520 Delaware St. S. E.
Charles H. Clevenger, M.S., Instructor in Mathematics and Mechanics 1214 7th St. S. E.
Edward W. Davis, B.S., Instructor in Mechanics and Mathematics 979 14th Ave. S. E.
Ernest O. Dieterich, Ph.D., Instructor in Physics 809 Essex St. S. E.
Gerhard Dietrichson, Ph.D., Instructor in Chemistry 429 Walnut St. S. E.
J. Theodore Geissendoerfer, Ph.D., Instructor in German 967 14th Ave. S. E.
Ervin W. McCullough, E.M., Instructor in Metallurgy 934 E. Bayliss Ave., St. Paul
Howard D. Myers, C.E., Instructor in Drawing 516 Oak St. S. E.
Edmund Newton, E.M., Instructor in Metallurgy 941 14th Ave. S. E.
Edward P. Quigley, Instructor in Forge Work 2923 Chicago Ave.
William H. Richards, Instructor in Carpentry 1423 W. 27th St.
Edward H. Sirich, Instructor in Romance Languages 321 14th Ave. S. E.
Richard Wischkaemper, M.A., Instructor in German 979 14th Ave. S. E.
Arnold Kirkpatrick, Ph.B., Assistant in Chemistry 1703 Taylor Ave., St. Paul
Eloise Webster, Librarian 1514 W. 25th St.

GENERAL INFORMATION

The School of Mines was established by the Board of Regents in 1888, upon recommendation of the General Faculty of the University. The buildings and laboratories of the School are located on the main campus of the University. The mining districts of Minnesota are within a few hours, by rail, from Minneapolis. The heartiest coöperation exists between the various mine managements and the School, so that the mining properties are at all times open to parties from the school for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts. Students in the School of Mines have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

The School of Mines occupies the new building provided by the Legislature of 1913. In the basement are the assay and electro-metallurgical laboratories, together with machinery room, instrument room, balance room, furnace rooms, and necessary storerooms. On the first floor are the administrative offices, offices and lecture rooms of the departments of Metallurgy and Mine Plant and Mechanics. On the second floor are the offices, lecture rooms, and drafting rooms of the department of Mining, the ore dressing laboratory, and the library of the school. On the third floor are the offices, laboratories, and lecture rooms of the department of Metallography, junior drafting room, photographic dark rooms, blue printing room, and offices and computing rooms for the branch of the Experiment Station serving the Tax Commission.

DEGREES

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M. (Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four or five years, and vice versa, provided such candidate completes an additional year's work at the School and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and Architecture, and in the School of Analytical and Applied Chemistry, who contemplate taking a degree in this School after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thoro courses in mechanics, mathematics, surveying, physics, chemistry, and the necessary theory and practice of structural, mechanical and electrical engineering.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine if it has value for treatment. (d) *Mining Engineering*—to furnish material for treatment. (e) *Ore Testing*—to determine best methods of treatment. (f) *Ore Dressing*—furnishing products for metallurgical treatment. (g) *Metallurgy*—smelting and refining ores and ore dressing products; reduction to metals.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the state, to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the Tax Commission and to do such other work along the lines above outlined as may be requested by other state departments. Coöperation has been effected with the Minnesota Geological Survey and the School of Chemistry.

The Experiment Station is prepared to assist citizens interested in these lines of work; to assay specimens of ore, rocks, clays, and minerals found within the state free of charge.

In submitting samples the sender must state the exact location where each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the office of the Station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, The University of Minnesota, Minneapolis, Minnesota.

LIBRARY

The library occupies a well-lighted room, 55 feet by 61 feet, on the second floor of the School of Mines building. The books have been carefully selected and form a working collection of great value, not only to the faculty and students, but also the mining men of the state. Only books relating to mining, metallurgy, metallography, geology, and allied subjects are shelved in this library, the general University library as well as the public libraries of Minneapolis and St. Paul serving as reserve collections. The library is especially rich in complete sets of periodicals, transactions, and the reports of state and foreign mining departments. Foreign technical literature is well represented. A card index is kept of all articles of value and interest appearing in the leading periodicals.

ADMISSION

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology), and Metallurgical Engineer may be completed in either four or five years. Students may enter the School of Mines without preparation in Higher Algebra and Solid Geometry. Such students must enter the five-year courses. It is recommended that students who come poorly prepared in Mathematics enter the five-year courses.

Students may be admitted to the School of Mines either by certificate or examination, or both.

ADMISSION BY EXAMINATION

Entrance examinations are offered at the University during registration week, October 2 to 5. Candidates entering by this method must pass examinations in fifteen units so chosen as to satisfy the requirements outlined below. Certificates from the College Entrance Examination Board and from the High School Board are accepted in lieu of examinations in the subjects they represent. Those desiring to take examinations should notify the Registrar of the University in writing not later than August 31.

ADMISSION BY CERTIFICATE

Graduates of the following courses, provided their preparation satisfies the requirements outlined below, may be admitted.

1. Any four-year course of a Minnesota state high school or other accredited school in the state.

2. A four-year course of schools in any other state accredited to the state university of that state.

3. The Advanced Latin and Advanced English courses of the Minnesota state normal schools.

The applicant for admission should request the principal or superintendent to forward to the Registrar of the University a complete tran-

script of his high-school or preparatory-school record showing the number of weeks and hours per week spent upon each study, with the grades entered as *passed, passed with credit,* or *passed with honor.* Credential blanks prepared by the University must be used; these blanks may be secured upon application to the Registrar. Upon receipt of the credentials at the University the Registrar will notify the applicant with regard to his admission.

ENTRANCE REQUIREMENTS

FIVE-YEAR COURSES

English, three units; Elementary Algebra and Plane Geometry, one unit each; ten additional units, of which not more than four may be in Group F.

FOUR-YEAR COURSES

Same as five-year courses with the addition of one-half unit each of Higher Algebra and Solid Geometry. It is recommended that students who enter these courses review Higher Algebra and Solid Geometry. Those unable to carry freshman mathematics satisfactorily will be required to re-register in the five-year course.

LIST OF ENTRANCE SUBJECTS

The term *unit* means not less than five recitations of forty minutes each per week for a period of thirty-six weeks. In manual subjects and kindred courses, it means the equivalent of ten recitation periods per week for thirty-six weeks.

Group A. English. Four units.

Groun B. Languages. Latin, Greek, German, French, Spanish, Scandinavian, one to four units each.

Group C. History and Social Sciences. Ancient and Modern History, one unit each; English and Senior American History, one-half unit each; American Government, Economics, Economic History of England, and Economic History of the United States, one-half unit each; Commercial Geography, and History of Commerce, one-half or one unit each.

Group D. Mathematics. Elementary Algebra and Plane Geometry, one unit each; Higher Algebra, Solid Geometry, and Trigonometry, one-half unit each.

Group E. Natural Sciences. Physics and Chemistry, one unit each; Botany and Zoology, one-half or one unit each; Physiology, Astronomy, Geology, and Physiography, one-half unit each.

Group F. Vocational Subjects. Business Law and Business Arithmetic, one-half unit each; Elementary and Advanced Bookkeeping, one-

unit each; Stenography and Typewriting, one or two units. Freehand Drawing, Mechanical Drawing, and Shopwork, one or two units each. Agriculture, one to four units. Normal Training subjects, one to three units, provided the applicant has had one year of subsequent teaching experience.

DESCRIPTION OF SUBJECTS ACCEPTED FOR ADMISSION

A description of the subjects accepted for admission to the University will be found in the Bulletin of General Information, which will be sent to any address upon application to the Registrar, The University of Minnesota, Minneapolis.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

ADMISSION TO ADVANCED STANDING

This University accepts records from all reputable colleges and universities for credit to advanced standing. Such records are accepted as far as they are equivalent to the work done in this institution. In bringing records from other institutions, the certificate must be upon the official blank of the institution granting the certificate and should show:

(a) The subject studied; if a language, the books read, etc.
(b) The number of weeks and hours per week spent upon each subject.
(c) Ground covered in laboratory work in case of laboratory subjects.
(d) The result. The exact grades should be stated, accompanied by an explanation of the marking system employed.

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee of the School of Mines.

EXPENSES

One half of the Annual Incidental Fee of $55, which includes all laboratory charges, is payable at the opening of each semester. Cards entitling the student to admission to classes will not be issued until the fees have been paid. Books and supplies for each year of the course cost approximately $25. Field-work expense during the sophomore year is estimated at $150 and for the junior year at $225.

DEPOSIT FEE

At the beginning of each year, in addition to the first semester incidental fee, a deposit fee of five dollars is required of every student to cover the following items:

Change of Registration..... $2.50
Examination for removal of condition at set time...$1.00 per subject
Rental of post-office box, University post-office (required of all) ..... $.50 per year
Locker rental, locker key deposit.....$.50 to $1.00 per year
Laboratory breakages, or damage to University property.
Penalties for late registration or late payment of fees.

A penalty fee of one dollar ($1) must be paid by all students who register or pay fees after the prescribed time. (See calendar, page 3.) After the day previous to that on which classes begin, the penalty for delay increases at the rate of twenty-five cents a day.

The unused balance of the deposit fee will be returned at the end of each year. If, at any time during the college year, the amount of charges against a student exceed the amount of the deposit, a second fee of five dollars ($5) will be required.

SPECIAL FEES

The following special items may be included in the expenses of a student:

Minnesota Union membership, required.....$1 per semester
Special examination for removal of condition, at other than the set time 5.00
Examination on subject taken out of class..... 5.00
No fee for such examinations on first entering the University, if taken within the first six weeks.
Military uniform, required of all freshmen and first-year students 15.00
Gymnasium suit 5.00

THE ELLIOT SCHOLARSHIP LOAN FUND

To fulfill the wish of the late Dr. A. F. Elliot to aid young men who find their efforts to obtain a practical education embarrassed through lack of means, the sum of $5,000 was placed in the hands of the Board of Regents as a scholarship fund. The income from this fund is loaned students in the School of Mines on the following conditions: the financial needs of the applicant, his scholarship, moral character, enthusiasm shown in his work, and promise of usefulness in his profession. When money is available, it may be loaned to pay the expenses of worthy students during sickness. The loans are to be repaid, without interest, at the earliest convenience of the recipients.

GRADUATION

Students completing courses of study to the satisfaction of the Faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in

all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the Faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations held at the end of the second semester. Irregular attendance will debar a student from entering all final examinations.

THESIS

The thesis work is intended to bring in review and connect the work in Mining and Metallurgy, Geology and Mineralogy, Mechanical and Electrical Engineering, Mathematics and Mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of Field Work at the School of Mines, Tuesday, October 2, 1917, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the School.

SPECIAL NOTES

Students failing to receive a semester mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his average in all subjects and present himself for supplementary examinations, according to the program given on page 4.

Failure of the Registrar to notify a student of deficiencies will not be accepted as a reason for neglecting to report for necessary supplementary examinations. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

Students failing to receive a semester mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The Faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination at the end of the first or second semester will be given zero on the examinations.

Students whose absences in either semester exceed four weeks in the aggregate are not permitted to take examinations without special permission of the Faculty.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

During the academic year students will be held responsible for the receipt of official communications sent to them through the University post-office. During the summer vacation they will be held responsible for the receipt of such communications sent to the home address given on registration blank for the preceding academic year, unless formal notification of their correct address is filed with the Registrar and the Dean.

COURSES OF STUDY

UNIFORM CURRICULUM TO END OF SOPHOMORE YEAR

The courses leading to the degrees of Engineer of Mines, Engineer of Mines in Geology, and Metallurgical Engineer, are uniform for the first three years of the five-year courses and for the first two years of the four-year courses.

Five-Year Courses

FIRST YEAR

First Semester

Chemistry 5*, General and Analytical, 5†
Mathematics 1, Computation and Mensuration, 4
Mathematics 3, Mine Accounting, 6
Mechanical Engineering 1, Shop Work, 6
Mineralogy 23, Elements of Mineralogy, 8
Military Drill

Second Semester

Chemistry 6, General and Analytical 7, Chem. 5
Mathematics 2, Algebra, 4
Mechanical Engineering 1, Shop Work, 6
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23
Military Drill

FRESHMAN YEAR

First Semester

Chemistry 11, Quantitative Analysis, 7, Chem. 5, 6
Drawing 11, Engineering Drawing, 10
Geology 105, Elements of Rock Study, 4, Mineral. 24
Mathematics 5, Algebra and Trigonometry, 6, Math. 1, 2
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Military Drill

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* Odd numbers indicate first-semester courses; even numbers, second-semester courses. A combination of the two (e.g., 5-6) indicates courses continuing through the year. In the case of courses repeated the second semester, the suffix *a* indicates first semester; the suffix *b*, second semester.

† Figure following the descriptive name of a course indicates number of hours a week. Course names following indicate prerequisite courses.

Second Semester

Chemistry 12, Quantitative Analysis, 7, Chem. 11
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Geology 1b, General Geology, 3, Mineral. 24
Geology 106, Petrology, 4, Geol. 105
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Military Drill

SOPHOMORE YEAR

First Semester

Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Mathematics 7, Calculus, 5, Math. 6
Geology 73, Historical and Economic Geology, 3, Geol. 106
Metallurgy 105, Base Metals, 4, Met. 4
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1

Second Semester

Drawing 14, Drafting, 4, Draw. 13
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Field Work. Months of May, June, July, and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geol. 1b, 105, beginning about June 15
Underground Mining Work, beginning about July 1

Four-Year Courses

FRESHMAN YEAR

First Semester

Chemistry 5, General and Analytical, 5
Drawing 11, Engineering Drawing, 10
Mathematics 5, Algebra and Trigonometry, 6
Mineralogy 23, Elements of Mineralogy, 8
Military Drill

Second Semester

Chemistry 6, General and Analytical, 7, Chem. 5
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23
Military Drill

SOPHOMORE YEAR

First Semester

Chemistry 11, Quantitative Analysis, 7, Chem. 5, 6
Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Geology 105, Elements of Rock Study, 4, Mineral. 24
Mathematics 7, Calculus, 5, Math. 6
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1
Military Drill

Second Semester

Chemistry 12, Quantitative Analysis, 7, Chem. 101
Drawing 14, Drafting, 4, Draw. 13
Geology 1b, General Geology, 3, Mineral. 24
Geology 106, Petrology, 4, Geol. 105
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Military Drill
Field Work. Months of May, June, July, and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geol. 1b, 105, beginning about June 15
Underground Mining Work, beginning about July 1

COURSES IN MINING ENGINEERING

COURSES LEADING TO THE DEGREE OF E.M.

Five-Year Courses

JUNIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 5, Ore Dressing, 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 6, Ore Dressing 4, Met. 5
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering 53, Electric Power, 5, Physics, 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng. 21
Mechanics 16, Mine Plant Design, 10, Mech. 15
Metallurgy 8, Special Problems, 4, Met. 7
Mining 12, 5, Min. 11
Mining 14, Thesis, 12, Min. 13

Four-Year Courses

JUNIOR YEAR

First Semester

Experimental Engineering 21, Steam Laboratory, 4, with Mech. 11
Geology 73, Historical and Economic Geology, 3, Geol. 106, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 105, Base Metals, 4, Met. 4
Metallurgy 5, Ore Dressing, 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 22, Strength of Materials, 4, with Mech. 10
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 6, Ore Dressing 4, Met. 5
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about June 1

SENIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Experimental Engineering 24, Experimental Laboratory, 4, Exp. Eng 21
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Metallurgy 8, Special Problems, 4, Met. 7
Mechanics 16, Mine Plant Design, 10, Mech. 15
Mining 12, 5, Min. 11
Mining 14, Thesis, 12, Min. 13

DEPARTMENT OF MINING ENGINEERING

The department is well supplied with samples of the smaller mine equipment, models, drawings, photographs, lantern slides, and mine maps. The lectures treat of prospecting, development, support of excavations, mining methods, mine administration, mining law, and the necessary allied subjects. The courses in Mining Engineering extend through the sophomore, junior, and senior years.

MINE SURVEYING

The work in surveying is given in the sophomore year and is designed solely for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi or Vermilion Range. The exact location will be announced in March of each year.

The students will be divided into squads of two to four. Each squad must provide itself with a 6-foot steel tape graduated to hundredths. The duration of the course will be seven weeks (5½ days of 8 hours each constitute a week). Each student will be required to complete satisfactorily the following exercises and surveys:

1. Chaining and taping
2. Compass work
3. Adjustment and use of wye and dumpy levels
4. Adjustment of mining transit
5. Reading angles
6. Traverse with transit and steel tape
7. Azimuth traverse with stadia
8. Determination of meridian, latitude, and time by solar and stellar observations
9. Survey of mining claim according to the regulations of the U. S. Government
10. Measurement of earthwork
11. Laying out railroad tangents, curves, and crossings
12. Exercises in plane table work and geological surveying
13. The survey of a mine

A full equipment of surveying instruments of the latest and best makes is furnished to each squad for this work.

This is followed by a course in Mine Mapping during the second semester of junior year.

Students who furnish satisfactory evidence of proficiency in this work may be given credit therefor. The department, however, reserves the right in any case to require such students to take a theoretical or a practical examination or both.

FIELD WORK IN MINING

Sophomore Year

After the close of the field work in Geology (last two weeks in June), members of the sophomore class are required to engage for six weeks in underground mining work on the Minnesota or Michigan iron ranges, for which they may receive wages.

Junior Year

Upon termination of the junior field work in Metallurgy (about May 15), the members of the junior class, who are candidates for the degree of Engineer of Mines, are required to devote two weeks to the study of mine plant and mine operation under the direction of the department. This work will be given in one of the leading western metal mining districts, exact location to be announced in April of each year. Thereafter, during the months of June, July, and August, the student is required to spend at least six weeks in actual underground mining work in the West, for which he may receive wages. The department will render all possible assistance in locating students in districts of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must in person submit this diary to the department on the date of the reopening of field work. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, October 2, 1917. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering Field Work in Mining and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned: Metallurgy, October 2-9, inclusive; Mining and Mine Plant, October 10-22.

On October 22 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 22. These reports shall become the property of the School.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reasons, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

COURSES LEADING TO THE DEGREE OF E.M. (GEOLOGY)

JUNIOR YEAR

First Semester

Geology 73, Historical and Economic Geology 3, 106, 1b
Geology 151, Advanced General Geology 3, 73
Geology 131, Advanced Petrology 5, 106, 1b
German 1 or 21, 6
or
French 1 or 3, 3
Metallurgy 155, Metallography 4
Mining 9, 5, Min. 6
Elective 6

Second Semester

Geology 124, Structural and Metamorphic Geology 3, 73
Geology 132, Advanced Petrology 5, 131
Geology 144, Construction and Interpretation of Geologic Maps 3, 111
Geology 150, Field Geology 8, 124
Geology 152, Advanced General Geology 3, 151
German 3 or 22, 6, German 1 or 21
or
French 1 or 3, 6
Metallurgy 156, Metallography 4, 155
Mining 10, 5, Min. 9
Mining 4, Mine Mapping 6, Min. 2f

SENIOR YEAR

First Semester

Geology 111, Ore Deposits 4, 73
Geology 11, Paleontology 3, 1b
Mining 11, 5, Min. 10
Thesis 2
Elective 12

Second Semester

Geology 112, Problems in Ore Deposits 4, 111
Geology 12, Paleontology 3, 11
Mining 12, 5, Min. 11
Thesis 4
Elective 9

FIELD WORK IN GEOLOGY

At the end of the sophomore year mining students are required to devote about three weeks to geologic mapping. This course usually comes after a six weeks' course in surveying and the fields chosen are the Vermilion and Mesabi iron ranges of Minnesota. This work is intended to train the students in the interpretation of field relations and the preparation of geologic maps and cross sections.

The second field course in geology is required only of those students who are candidates for the E.M. in Geology degree. The course begins early in May and is completed in June. The course requires altogether about six weeks work, and the field chosen is the Black Hills region of South Dakota or some other western region. The student is trained in the interpretation of field data; in detailed mapping, underground and on the surface; in the preparation of geologic cross sections through mines; and he may gather material which will serve as a basis for future study in advanced courses the following year. The work conforms with the standards of official surveys as nearly as practicable. At the close of the field season the students are expected to obtain positions with mining companies either as miners or as engineers, or if openings are available, they may enter geological surveys for the season's work.

COURSES IN METALLURGY

COURSES LEADING TO THE DEGREE OF MET. E.

Five-Year Courses

JUNIOR YEAR

First Semester

Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 5, Ore Dressing, 4, Geol. 23 and 24
Metallurgy 13, Ore Dressing Lab. 4, Geol. 23 and 24
Metallurgy 153, Metallography 7, Chem. 12, Physics 1 and 2
Mining 9, 5, Min. 6

Second Semester

Geology 112, Problems in Ore Deposits, 4, Geol. 111
Mechanics 10, 6, Mech. 9
Mechanics 14, Met. Plant, 2, Mech. 11
Metallurgy 6, Ore Dressing, 4, Met. 5 and 13
Metallurgy 14, Ore Dressing, Lab. 4, Met. 5 and 13
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Practical work in mills and smelters beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering, 53, Electric Power, 5, Physics, 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 5, 6, 106
Metallurgy 11, Thesis, 8, Met. 106, Met. 5, 6, and 13
Metallurgy 109, Electrometallurgy, 8, Met. 3, 4, 105, 106

Second Semester

Metallurgy 8, Special Problems, 8, Met. 7
Metallurgy 10, Advanced Metallurgy 10, Met. 7
Metallurgy 16, Thesis, 18, Met. 11

Four-Year Courses

JUNIOR YEAR

First Semester

Geology 73, Historical and Economic Geology, 3, Geol. 106, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant 5, Math. 8
Metallurgy 105, Base Metals, 5, Met. 4
Metallurgy 5, Ore Dressing, 4, Geol. 23 and 24
Metallurgy 13, Ore Dressing Lab. 4, Geol. 23 and 24
Metallurgy 153, Metallography 7, Chem. 12, Physics 1 and 2
Mining 9, 5, Min. 6

Second Semester

Mechanics 10, 6, Mech. 9
Mechanics 14, Met. Plant 2, Mech. 11
Metallurgy 6, Ore Dressing 4, Met. 5 and 13
Metallurgy 14, Ore Dressing Lab. 4, Met. 5 and 13
Metallurgy 106, Precious Metals, 5, Met. 105
Metallurgy 154, Metallography 7, Met. 153
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Practical work in mills and smelters beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Geology 111, Ore Deposits, 4
Mechanics 13, Water Power, 5, Mech. 10
Metallurgy 7, Ore Testing 10, Met. 5, 6, 105, and 106
Metallurgy 11, Thesis, 8, Met. 106, Met. 5, 6, and 13
Metallurgy 109, Electrometallurgy, 8, Met. 3, 4, 105, and 106

Second Semester

Geology 112, Problems in Ore Deposits, 4
Metallurgy 8, Special Problems, 8, Met. 7
Metallurgy 10, Advanced Metallurgy 10, Met. 7
Metallurgy 16, Thesis, 18, Met. 11

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in Metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags are shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their reports in detail. This work is offered to students completing the necessary courses in Mineralogy and Chemistry.

ORE DRESSING

The lectures and recitations in Ore Dressing extend through the junior year, and comprise the detailed study of ore dressing and concentrating machinery, together with the study of typical combinations of dressing machines as found in the several mining districts of the United States. In connection with the theoretical work, the ore dressing laboratory and testing plant of the School is utilized for practical illustrations.

ORE TESTING

The lectures treat of the use and purposes of all the machinery connected with the subject, supplemented by detailed drawings. There are complete testing works, connected with the department where the student may see the working of, and handle for himself crushers, rolls, and concentrating machinery, as well as sizing apparatus and hydraulic separators. Sufficiently large amounts of ore are given to make the necessary tests upon the different machines and the students report the best method of treatment. The courses run through the senior year and are required of students both in Mining and Metallurgy.

The ore-testing works meet educational, as well as commercial, needs.

Educational.—The ore-testing plant acquaints the student with the construction and manipulation of the principal typical machines used in the leading ore-dressing establishments of the country. It is here that students in Mining and Metallurgical Engineering get the requisite practical experience. They handle all machines and operate on sufficiently large amounts of material to determine the methods best suited to a given ore to extract the largest amount of metal with the least possible loss.

Commercial.—Ore-testing works are an important factor in mining and metallurgical projects. The commercial object is to determine the best method of treating a given ore so as to yield the largest percentage of the metal it contains at the least possible cost. Samples varying from 500 pounds to car-load lots can be treated by various methods.

As the funds appropriated for the erection of such a plant were sufficient to purchase only the necessary machinery, the business men of Minneapolis generously provided a suitable building. This building, 94 by 66 feet, is built of brick and stone.

FIELD WORK IN METALLURGY

At the end of the junior year students are required to study practical operations at one or more smelters and mills. This work will begin about May 1. Not over three weeks' time will be devoted to this work.

Upon termination of the junior field work in Metallurgy and one week in Mining (not later than June 1), the members of the junior class who are candidates for the Degree of Metallurgical Engineer, are required to spend at least six weeks in practical work in one or more of the smelters or mills, for which they may receive wages. The department will render all possible assistance in locating students in districts of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must, in person, submit this diary to the department on the date of reopening of field work at the School. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below standard.

Field work will reopen at the School of Mines, Tuesday, October 2, 1917. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering field work in Metallurgy and Mining must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: Metallurgy, October 2-9, inclusive; Mining and Mine Plant, October 10-22.

On October 22 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling opera-

tions, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 22. These reports shall become the property of the School.

METALLOGRAPHY

Courses in Metallography are offered to seniors who are candidates for the degree of Metallurgical Engineer, students in the Colleges of Science, Literature, and the Arts, Engineering, Chemistry, and the Graduate School.

These courses deal with the microscopic examination of metals, alloys, and ores. The lectures treat of and describe the apparatus used in connection with this subject, the methods of preparing specimens, the physical, chemical, and metallurgical principles involved, and the interpretation of the results of microscopic examination. A collection of specimens, microphotographs, and lantern slides covering wrought iron, low carbon, structural, rail, and tool steels, brasses, bronzes, and other industrial alloys are available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals, alloys, and ores. The laboratory is equipped with microscopes, electric and portable gas furnaces, and pyrometers of the latest and improved types. A special dark room is available for the preparation of microphotographs.

DEPARTMENTAL STATEMENTS

EXPLANATION OF COURSE NUMBERS

Odd numbers indicate first-semester courses; even numbers, second-semester courses. A combination of the two (e.g., 5-6) indicates courses continuing through the year. The suffixes *a* and *b* apply to one-semester courses offered both semesters, *a* indicating the first semester and *b* the second semester (e.g., 3a,b; 4a,b). The suffix *f* indicates summer field work.

All undergraduate courses are numbered from 1 to 100. All courses open to undergraduates and graduates are numbered from 101 to 200. Strictly graduate courses are numbered from 201 up.

CHEMISTRY

Professors George B. Frankforter, Charles F. Sidener; Assistant Professor Sterling Temple; Instructor Gerhard Dietrichson; Assistant Arnold Kirkpatrick.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
5.	Gen. & Anal. Chemistry.....	3	2	All Fr.	..
6.	Gen. & Anal. Chemistry.....	1	6	All Fr.	5
11.	Quantitative Analysis	1	6	All Soph.	6
12.	Quantitative Analysis	1	6	All Soph.	11
24.	Iron & Steel Analysis.....	1	6	Elective	12
25.	Ore & Slag Analysis.....	1	6	Elective	12
144.	Electrochemistry	1	4	Elective	12

5-6. General and Analytical Chemistry. An introduction to descriptive, physical, and metallurgical chemistry and qualitative analysis. Frankforter, Temple, and Assistants.

11-12. Quantitative Analysis. A general discussion of quantitative methods, with laboratory work in gravimetric analysis, first semester; followed by a discussion of standard solutions and the necessary stoichiometric calculations with laboratory work in volumetric analysis, second semester. Sidener, and Assistants.

24. Iron and Steel Analysis. Includes technical methods for the determination of the common constituents of iron ores, iron, and steel, with training in rapid work. Sidener, and Assistants.

25. Ore and Slag Analysis. Rapid technical method for the determination of certain constituents in ores and slags. Sidener.

144. Electrochemistry. A discussion of electro-analytical methods and industrial electrochemical processes, and their underlying principles. Dietrichson.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor WILLIAM H. KIRCHNER; Assistant Professor ROBERT W. FRENCH; Instructor HOWARD D. MYERS.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11.	Engineering Drawing	..	10	All Fr.	..
12.	Engineering Drawing	..	8	All Fr.	11
13.	Descriptive Geometry	2	..	All Soph.	12, Math. 6
14.	Drafting	..	4	All Soph.	13

11. ENGINEERING DRAWING. Sketching, lettering, representation, parallel and radial projection, elements of engineering representation, details of machines and structures, interpretation of working drawings. KIRCHNER, MYERS.

12. ENGINEERING DRAWING. Continuation of Course 11 as outlined above. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Maps and sketches. Brushes and pen conventions. MYERS.

13. DESCRIPTIVE GEOMETRY. Projection; central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. KIRCHNER.

14. DRAFTING. Graphics, machine drafting, and structural drafting. Instruction in drafting room methods. FRENCH.

ELECTRICAL ENGINEERING

Professor GEORGE D. SHEPARDSON; Assistant Professor WILLIAM T. RYAN.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
53.	Electric Power	2	2	Sr. E. M. & Met. E.	Physics 3, 4

53. ELECTRIC POWER. Elements of theory and practice of electrical measurements, wiring, dynamos, motors, and electric lighting. RYAN.

EXPERIMENTAL ENGINEERING

Assistant Professors CHARLES F. SHOOP, FRANKLIN R. MCMILLAN, FRANK B. ROWLEY.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
21.	Steam Laboratory	..	4	Jr. E. M. & Met. E.	With Math. 11
22.	Strength of Materials	..	4	Jr. E. M. & Met. E.	With Math. 10
24.	Experimental Laboratory	..	4	Sr. E. M. & Met. E.	21

21. Steam Laboratory. Exercises in valve setting, indicator practice, calibration of steam gauges, efficiency of screws and hoists. Shoop.

22 Strength of Materials. Laboratory work, investigating the strength and physical qualities of iron, steel, brass, cropper, belting, chains, beams, brick, and stone. McMillan.

24. Experimental Laboratory. Hydraulic measurements. Calibration of weirs, nozzles, meters, and other hydraulic apparatus, calorimetry; tests of pumps, engines, and boilers. Rowley.

GEOLOGY AND MINERALOGY

Professor William H. Emmons; Associate Professors Clinton R. Stauffer, Frank F. Grout; Assistant Professors A. Walfred Johnston, Terence T. Quirke; Instructor Thomas M. Broderick.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1b.	General Geology	3	..	All Soph.	24
1f.	Field Work	..	2 wks.	All Soph.	1b and 105
11.	Paleontology	3	..	Sr. E. M. (Geol.)	1b
12.	Paleontology	3	..	Sr. E. M. (Geol.)	11
23.	Elements of Mineralogy	4	4	All Fr.	..
24.	Descriptive Mineralogy	2	2	All Fr.	23
73.	Histor. & Econ. Geology	3	..	All Jr.	1b and 105
105.	Elements of Rock Study	..	4	All Soph.	24
106.	Petrology	..	4	All Soph.	105b
111.	Ore Deposits	4	..	Sr.E.M.&E.M.(Geol.)	106
112.	Problems in Ore Deposits	..	4	Sr.E.M.&E.M.(Geol.)	111
124.	Struct. & Metamorph. Geol.	3	..	Jr. E. M. (Geol.)	73 and 105
131.	Advanced Petrology	2	3	Jr. E. M. (Geol.)	106, 1b
132.	Advanced Petrology	2	3	Jr. E. M. (Geol.)	131
137.	Testing Econ. Minerals	1	4	Elective	24, 73
140.	Applied Petrology	1	4	Elective	See statement
144.	Construction & Interpretation of Geologic Maps	..	4	Elective	73
150.	Field Geology	..	..	Jr. E. M. (Geol.)	124
151.	Advanced General Geology	3	..	Jr. E. M. (Geol.)	73
152.	Advanced General Geology	3	..	Jr. E. M. (Geol.)	151
246.	Pre-Cambrian Geology	3	3	Elective	124
247.	Geol. & Exploration of Lake Superior region	3	..	Elective	124

1b. General Geology. A synoptical treatment of materials of the earth and of geologic processes. Physiographic, dynamic, and structural geology, with a brief introduction to Historical Geology. Johnston.

1f Field Work. About two weeks in June are spent in geologic mapping of selected areas in the iron districts of Minnesota. Involves preparation of geologic maps, and written reports.

11. Paleontology. A study of fossil forms with special reference to those of geological importance. Stauffer.

12. Paleontology. Faunas and their correlation. A continuation of Course 11. Stauffer.

23. Elements of Mineralogy. The crystal systems; morphological, physical, and chemical character of minerals; occurrence, genesis, and uses of minerals; classifications and description of common minerals. Determinative work in laboratory, blowpipe analysis, sight identification. Broderick, Grout.

24 Descriptive Mineralogy. A continuation of Course 23, special attention being given to metalliferous and rock-forming minerals. Laboratory determination and sight identification. The use of the goniometer and microscope. Laboratory work, reference reading, and field excursions. Broderick, Grout.

73. Historical and Economic Geology. (a) Historical Geology. The geologic history of North America, with special reference to its syngenetic mineral deposits. (b) Economic Geology. A study of the non-metallic minerals of economic value, and discussions of the geologic guides to prospecting for these deposits. Emmons, Quirke.

105. Elements of Rock Study. The occurrence and genesis of igneous sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. Grout, Broderick.

106. Petrology. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and metamorphic rocks. The origin and classification of rocks. Grout, Broderick.

111. Ore Deposits. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. Emmons.

112. Problems in Ore Deposits. Field excursions, map work, lectures on field and laboratory methods. Emmons.

124. Structural and Metamorphic Geology. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. Johnston.

131-132. Advanced Petrology. Advanced optical methods. Criteria for rapid identification of minerals and rocks. The uses of schedules and tables. Standard rock types. Regional and genetic studies. Petrographic reports. Grout.

137. Testing Economic Minerals. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, oil, building stone, and metallic ores. Grout.

140. Applied Petrology. To follow or accompany Course 132. Determination of transparent and opaque ores and gangue minerals. Microscopic studies of paragenesis of ores and other mineral associations by means of reflecting light. Practical petrographic problems. Grout.

144. Construction and Interpretation of Geologic Maps. Hours to be arranged. Methods of geologic examination; problems in construction and interpretation of geologic maps and sections, with special reference to underground mapping of metalliferous areas. Quirke.

150. Field Geology. Detailed and systematic work conforming with standards of official surveys. Preparation of geologic maps, structure sections, and reports; a study of the paragenesis of ores and their relations to geologic structures. Field for 1917-18, Black Hills, South Dakota. Johnston, Emmons.

151. Advanced General Geology. Geologic processes and their results; development of the North American continent. Stauffer.

152. Advanced General Geology. A continuation of Course 151. Stauffer.

246. Pre-Cambrian Geology. The problems of pre-Cambrian correlation and structure; the pre-Cambrian stratigraphy of North America. Given in alternate years. Three credits. Not offered in 1916-17. Johnston.

247. Geology and Exploration of Lake Superior Region. The geology of the Lake Superior iron districts. The methods used in the exploration of iron ore; interpretation of drill cores; cartographic expression of drill data; models of drilled areas. The principles of magnetic surveying. Three credits. Johnston.

GERMAN LANGUAGE AND LITERATURE

Professor Carl Schlenker; Assistant Professors Oscar C. Burkhard, Samuel Kroesch, Walter R. Myers; Instructors James Davies, Lynwood G. Downs, J. Theodore Geissendoerfer, Richard Wischkaemper.

COURSES

No.	Title	Rec. hrs.	Required of	Prerequisite courses
1a,b.	Beginning	6	Jr. E. M. (Geol.)	..
3a,b.	Intermediate	6	Jr. E. M. (Geol.)	1a,b.
5-6.	Prose and Poetry	6*	Elective	2 yrs. prep. German
11-12.	Rapid Reading	6*	Elective	3a or 3b
21-22.	Scientific Intermediate	6*	Elective	1-3 or equivalent
23-24.	Adv. Scientific Reading	6*	Elective	5-6 or 4 yrs. prep. Ger.

* Both semesters must be completed before credit is given for either semester.

1a,b. Beginning. Double course. Pronunciation, grammar, conversation, and composition; selected readings in easy prose and verse. Kroesch, Myers.

3a,b. Intermediate. Double course. Selected texts in modern narrative and descriptive prose; selected lyrics and ballads; a drama of Lessing, Goethe, or Schiller. Assigned reading of texts outside of class. Kroesch, Myers, Frary.

5-6. Prose and Poetry. Geography, history, and legend. Review of German grammar throughout the year. Burkhard, Downs.

11-12. Rapid Reading. First semester: narrative prose; Hauff, Storm, Sudermann, Goethe's *Hermann und Dorothea*. Second semester: Plays of Lessing, Goethe, Schiller, Hebbel. Assigned readings and reports. Davies.

21-22. Scientific Intermediate. This course aims to give students a reading knowledge of German for use in scientific studies. Wait's German Science Reader (or equivalent). Geissendoerfer, Graves.

23-24. Advanced Scientific Reading. Reading of monographs and periodicals. Not open to those who have credit for Course 7-8. May be supplemented by Course 20-30. Wischkaemper.

MECHANICAL ENGINEERING

Professor John J. Flather; Assistant Professor S. Carl Shipley; Instructors Edward Quigley, William H. Richards.

COURSES

No.	Title	Lab. hrs.	Required of	Prereq. courses
1a.	Pattern Making	6 (9 wks.)	1st-yr. E. M. & Met. E.	..
1b.	Foundry	6 (9 wks.)	1st-yr. E. M. & Met. E.	..
1c.	Forge	6 (9 wks.)	1st-yr. E. M. & Met. E.	..
1d.	Machine & Bench work	6 (9 wks.)	1st-yr. E. M. & Met. E.	..

1a. Pattern Making. Use of tools, lathe and bench work, making of timber joints, core boxes, and flasks. Richards.

1b. Foundry. Molding, core making, mixing and casting metals. Quigley.

1c. Forge. Use of tools, forging, welding, tool dressing and tempering. Quigley.

1d. Machine and Bench Work. Use of tools and elementary machine operations. Shipley.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Assistant Professor Samuel L. Hoyt; Instructor Ervin W. McCullough.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
2.	Assaying	4	8	All Fr.	Chem. 5, Mineral, 23
3.	Gen. Met. & Iron & Steel	3	..	Soph. E. M. & Met. E.	2, Chem. 6
4.	Wrought Iron & Steel	3	..	Soph. E. M. & Met. E.	3
5.	Ore Dressing	4	..	All Jr.	..
6.	Ore Dressing	4	..	All Jr.	..
6f.	Field Work in Metallurgy.	..	10 dys	Jr. E. M. & Met. E.	Satisfactory completion of Jr. year
7.	Ore Testing	2	8	Sr. E. M. & Met. E.	106, 5
8.	Special Problems in Ore Testing	..	4	Sr. E. M. & Met. E.	7
10.	Advanced Metallurgy	2	8	Sr. Met. E.	7
11.	Thesis in Metallurgy	..	8	Sr. Met. E.	106, 5
13.	Ore Dressing Lab.	..	4	Jr. Met. E.	Geol. 23 & 24
14.	Ore Dressing Lab.	..	4	Jr. Met. E.	5 & 13
16.	Thesis & Specifications	..	18	Sr. Met. E.	11
105.	Met. of Base Metals	4	..	Jr. E. M. & Met. E.	4
106.	Met. of Precious Metals	4	..	Jr. E. M. & Met. E.	105
109.	Electrometallurgy	3	..	Sr. Met. E.	2, 4, 105, 106
153.	Metallography	3	4	Jr. Met. E.	Chem. 12, Phys. 1 & 2
154.	Metallography	3	4	Jr. Met. E.	Met. 153
157.	Metallog. for Engineers	3	4	Elective	Mech.Eng.3 & 4
158.	Adv. Met. for Engineers	3	4	Elective	Met. 157
160.	Metallog. for Chemists	2	2	Elective	Chem. 12
161.	Dental Metallography	3	..	Elective	..
163.	Advanced Metallog.	To be ar.		Elective	Met. 154
164.	Advanced Metallog.	To be ar.		Elective	..

2. ASSAYING. Determination of values of ores, metallurgical products, and bullion. APPLEBY and Assistants.

3. GENERAL METALLURGY AND METALLURGY OF IRON. Including the subjects of combustion, fuels, refractory materials and furnaces. Lectures and recitations on metallurgy of iron. CHRISTIANSON.

4. METALLURGY OF WROUGHT IRON AND STEEL. Puddling and hearth processes for the production of wrought iron. Cementation, crucible, Bessemer and open hearth processes for the production of steel. General principles and construction of furnaces. CHRISTIANSON.

5-6. ORE DRESSING. Examination of ores, crushing, sizing classification, and methods of mechanical separation. MCCULLOUGH.

6f. FIELD WORK IN METALLURGY. Study of metallurgical operations at smelters and mills. Detailed report is required covering plants visited. CHRISTIANSON, PEASE.

7. ORE TESTING. Determinations of methods of ore treatment, stamping, concentration, cyanidation, roasting, amalgamation and flotation. CHRISTIANSON and Assistants.

8. Special Problems in Ore Testing. Continuation of Course 7. Assay of mill and smelter products so as to regulate smelting charges and roasting operations. Pease and Assistants.

10. Advanced Metallurgy. Pyrometry, calorimetry, metallurgical calculations to determine heat distribution and heat balance. Christianson.

11. Special Problems in Metallurgy. Research work preparatory to thesis. Appleby and Assistants.

13-14. Ore Dressing Laboratory. Practical problems in crushing, sizing, classification and concentration of minerals. McCullough.

16. Thesis and Specifications. Detailed investigations of ore treatment, with report including designs and specifications for suitable plants. Appleby and Assistants.

105. Metallurgy of the Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining methods. Pease.

106. Metallurgy of the Precious Metals. Gold, silver, and platinum. Methods and principles of cyanidation, chlorination, amalgamation, and lixiviation as applied to the treatment of the above. Pease.

109. Electrometallurgy. Application of electricity to the production of heat for the smelting of ores and refining of metals. Comparative costs of the use of fuel and electricity for heating purposes, relative efficiencies of electric and fuel furnaces. Construction of high temperature furnaces and commercial plants. Christianson.

153-154. Metallography. Theory of metallic alloys. Metallographic technique. Properties of metals and alloys. Metallography of iron and steel and commercial alloys. Technical metallography. Hoyt.

157. Metallography for Engineering Students. Metallurgy of iron and steel. Microscopic and thermal analysis of steel and cast iron; heat and mechanical treatment. Laboratory work. Hoyt.

158. Advanced Metallography. Continuation of Met. 157. Metallography applied to engineering practice; commercial heat treatment; uses and properties of alloy steels. Engineering specifications involving the use of metals and alloys. Laboratory work. Hoyt.

160. Metallography for Chemical Students. The preparation of metallic alloys; their microscopical and thermal analysis. Steel and other commercial alloys with particular reference to chemical metallurgy. Corrosion of steel and non-ferrous alloys. Metallography applied to analytical chemistry. Hoyt.

161. Dental Metallography. Study of the dental alloys from the standpoint of metallography. Hoyt.

163-164. Advanced Metallography. Technical and scientific research. The study of steel rails, automobile and locomotive parts, tool steels etc. Special problems in metallography with outside reading. Seminar work on the recent advances in metallography. Hoyt.

MINE PLANT AND MECHANICS

Professor Elting H. Comstock; Assistant Professor Edwin M. Lambert; Instructors Edward W. Davis, Charles H. Clevenger.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Computation & Mensuration.	3	..	All 1st-yr. students	..
3.	Mine Accounting	..	6	All 1st-yr. students	..
4.	Algebra	4	..	All 1st-yr. students	..
5.	Algebra & Trigonometry.....	6	..	All Fr.	1 & 2
6.	Spherical Trig. & Anal. Geom.	6	..	All Fr.	5
7.	Calculus	5	..	All Soph.	6
8.	Calculus	3	..	All Soph.	7
9.	Mechanics	5	..	All Jr.	8
10.	Mechanics	6	..	All Jr.	9
11.	Mine Plant	5	..	Jr. E. M. & Met. E.	8
12.	Mine Plant	6	..	Jr. E. M.	11
13.	Hydraulics & Water-Power..	5	..	All Sr.	10
14.	Metallurgical Power Plant..	2	..	Jr. Met. E.	11
15.	Engineering Construction ...	1	4	Sr. E. M. & Met. E.	10
16.	Mine Plant Design.....	..	10	Sr. E. M.	15
18.	Mill and Smelter Design....	..	6	Sr. Met. E.	15

1 Computation and Mensuration. Demonstrations of most important theorems of solid geometry. Volumes, approximate volumes, prismoidal formula, etc. Approximate computation, graphs, and graphical computation, logarithms and logarithmic computation, areas and approximations of areas, use of slide rule. Clevenger.

3 Elementary Mine Accounting. Elementary accounting in general; applications to mine accounts; primary records, labor, supply, mine and mill products, and fund sheets; secondary records, invoice, labor and supply, mine and mill cost sheets, trial balance. Lambert.

4. Algebra. Equations with one, two, or more unknown quantities, inequalities, involution and evolution, theory of exponents, surds, quadratic equations both numerical and literal, equations with one or more unknown quantities that can be solved by means of quadratic equations, progressions. Clevenger.

5 Algebra and Trigonometry. Functions and functional notation, factor and remainder theorems, factors and values of functions, determinants, development of functions, theory of equations, permutations and combinations; trigonometric ratios, right triangles, general definitions of trigonometric functions, analytic relations, addition formulas, trigonometric equations, and oblique triangles. Clevenger.

6. Spherical Trigonometry and Analytical Geometry. General properties and solution of spherical triangles; systems of coördinates, loci-equations and properties of the straight line, transformation of coordinates, equations and properties of conics, general equations of the second degree, higher plane curves, space coördinates, point, plane, straight line, quadric surfaces. Clevenger.

7. Calculus. Nature of differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, indeterminate forms, partial derivatives, change of variable. Lambert.

8. Calculus. Elementary integration, undetermined coefficients, rational fractions, rationalization, formulas of reduction, hyperbolic functions, some differential equations of mechanics. Lambert.

9. Mechanics. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy; elementary mechanics of materials. Clevenger.

10. Mechanics. Mechanical and elastic properties of materials of construction; beams, shafts, columns, reinforced concrete, hollow cylinders and spheres, rollers, plates; theory of internal stress. Clevenger.

11-12. Mine Plant. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. Comstock.

13. Hydraulics and Water-Power. Laws of the equilibrium, pressure, and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, speed control, power-house equipment, transmission. Comstock.

14. Metallurgical Plant. Power, air, and water supply for metallurgical plants. Comstock.

15. Engineering Construction. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures, design of mining structures. Lambert.

16. Mine Plant Design. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. Comstock.

18. Mill and Smelter Design. A study of the construction and mechanical equipment of mills and smelters in connection with thesis work. Comstock.

MINING ENGINEERING

Associate Professor JOHN F. MURPHY; Instructor ANDERS J. CARLSON.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Mine Surveying	3	..	All Soph.	Math. 6
2.	Mine Surveying	3	..	All Soph.	1
2f.	Field Work	..	7 wks.	All Soph.	2
4.	Mine Mapping	..	6	All Jr.	2f
6.	Mining	1	..	All Soph.	..
9.	Mining	5	..	All Jr.	6
10.	Mining	5	..	All Jr.	9
10f.	Practical Mining	..	2 wks.	All Jr.	Satisfactory completion of Jr. yr.
11.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	10
12.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	11
13.	Thesis	..	2	Sr. E. M.	10f
14.	Thesis	..	12	Sr. E. M.	13

1, 2. MINE SURVEYING. Computation, platting, and problems with special reference to mine surveying. LAMBERT.

2f. FIELD WORK. Practice in general surveying during the month of May. Practice in underground surveying during the first two weeks of June. This work is given on the Iron Ranges. LAMBERT, CARLSON.

4. MINE MAPPING. Mine mapping in accordance with prevalent practice in the western mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. MURPHY, CARLSON.

6 MINING. Introductory course in mining. MURPHY.

9. MINING. Occurrence of ore bodies, prospecting, churn and diamond drilling, drilling, blasting, excavation, tunneling and drifting. MURPHY.

10. MINING. Shaft sinking, underground mining methods, support of underground excavation. MURPHY.

10f. PRACTICAL MINING. Study of mining operations. Mine plant and equipment and practical mining work; a mine to be selected by department during months of May, June, July, and August. MURPHY, COMSTOCK, and Assistants.

11. MINING. Open pit mining, quarrying, coal mining, mining alluvial deposits. MURPHY.

12. MINING. Drainage, transportation, ventilation, mine sanitation and hygiene, mine examination, mine management, mining law, economics of mining. MURPHY.

13, 14. THESIS. Conference. Design and specifications of mining details required in thesis study. MURPHY and Assistants.

PHYSICS

Professors Henry A. Erikson, Anthony Zeleny; Instructor Ernest O. Dieterich.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	General Physics	3	..	All Soph.	Math. 6
2.	General Physics	3	..	All Soph.	1
3.	General Lab. Practice	..	2	All Soph.	With 1
4.	General Lab. Practice	..	2	All Soph.	With 2

1. General Physics. Mechanics of solids and fluids, sound and heat. Treatment experimental rather than mathematical; the fundamental principles. Zeleny, Dieterich.

2. General Physics. Electricity, magnetism, and light. Treatment experimental; the fundamental principles, including those of radioactivity, ionization, X-radiation, and the electrical constitution of matter. Zeleny, Dieterich.

3. General Laboratory Practice. Physical measurements in the mechanics of solids and fluids, and in heat and sound, giving the student a knowledge of experimental methods, and an intimate acquaintance with the fundamental facts of the subject. Dieterich.

4. General Laboratory Practice. Physical measurements in electricity, magnetism, and light. Dieterich.

ROMANCE LANGUAGES

Professor Everett Ward Olmsted; Assistant Professor Jules T. Frelin; Instructors Edward H. Sirich, Francis B. Barton, Harry E. Atwood.

COURSES

No.	Tile	Rec. hrs.	Required of	Prereq. courses
1b.	Beginning French	6	Jr. E. M. (Geol.)	..
3b.	Intermediate French	6	Jr. or Sr. E. M. (Geol.)	1b
5.	Survey French Lit.	3	Sr. E. M. (Geol.)	3b
6.	Survey French Lit.	3	Sr. E. M. (Geol.)	5

1b. Beginning French. Stress on accurate pronunciation, reading, reading vocabulary, and the essentials of grammar. Daily oral and written exercises (dictation and reproduction in French). Frelin, Sirich, Atwood, Barton.

3b. Intermediate. French grammar, composition, and reading; increased use of French in the classroom. Selections from modern prose and poetry. Frelin, Atwood, Sirich, Barton.

5-6. General Survey of French Literature. Lectures, recitations, and assigned readings. Designed to cover the whole period in historical outline. Selections from representative authors. Sirich, Atwood, Barton.

STUDENTS

SENIORS—15

Anderson, Edwin H., Oakes, N. D.
Cassilly, Thomas E., St. Paul
Coryell, Lewis S., Osceola, Wis.
Dennis, Richard C., Ashland, Wis.
Dopp, Lawrence, Ashland, Wis.
Elson, William H., St. Paul
Ernster, Omer F., Brainerd
Fearing, Edward J., Little Falls, Minn.
Hubbard, William E., Duluth
Kwong, Yih-Kum, Shanghai, China
Levorsen, A. Irving, Fergus Falls
Peterson, Paul A., St. Paul
Sweetman, Edwin A., Aitkin
Wallace, Carleton S., Minneapolis
Woodruff, John J., Minneapolis

JUNIORS—20

Ainsworth, Robert E., Minneapolis
Allard, Raymond W., St. Paul
Armstrong, Harold K., Minneapolis
Bailey, A. Kittredge, Minneapolis
Clark, Fred E., Minneapolis
Copeland, William A., St. Paul
Cowin, Percy G., Minneapolis
Dane, Carleton M., St. Paul
Dowdell, Ralph L., St. Paul
Foley, Lyndon L., Minneapolis
Frank, Harry, Minneapolis
Gannett, Roger W., Minneapolis
Hsieh, Chung, Kirin, China
Ingersoll, Guy E., Hibbing
Jerrard, Walter L., St. Cloud
McGilvra, Donald B., Minneapolis
Moga, John A., St. Paul
Nichols, Clifford R., Buhl
Quinn, Howard E., Melrose
Strand, Harry W., Marine Mills

SOPHOMORES—19

Abramson, Jake, Minneapolis
Barr, Joseph C., Riverton
Calhoun, Robert, Minneapolis
Berg, Locksley D., Dickinson, N. D.
Donaghue, Abner J., Minneapolis
Flom, Frank, Minneapolis
Frank, Elden J., Duluth
Frellsen, Sidney A., Minneapolis
Gandrud, Bennie W., Glenwood
Goldberg, Bert, St. Paul
Goldberg, Samuel B., St. Paul
Hosted, Joseph Orrin, Duluth
Mellem, Walter R., St. Paul
Miao, Yun Tai, Yunnanfu, China
Rockwell, Seass A., Fargo, N. D.
Sponberg, E. Clarence, Hibbing
Stark, James A., Duluth
Sullivan, Dan C., Stillwater
Wadsworth, Lawrence Hill, Minneapolis

FRESHMEN—19

Andersen, A. Clarence, Tyler
Arnold, Lewis E., Minneapolis
Bergsten, Axel, Florence, Wis.
Chadbourn, Charles H., Minneapolis
Davies, Herman F., Minneapolis
Donald, George A., Ashland, Wis.
Johnsen, Trygve, St. Paul
Johnston, Kenneth A., St. Paul
Mark, Israel C., Minneapolis
Mars, William P., Duluth
Munson, Arthur M., St. Paul
Olsen, Paul W., Minneapolis
Peterson, Clarence D. B., Minneapolis
Powers, Sheldon M., Minneapolis
Raiter, Clifford R., Minneapolis
Ringwood, Thomas E., Ashland
Rydlun, Edwyn G., Minneapolis
Thoeni, Victor T., Wyckoff, Minn.
Wheeler, James D., Minneapolis

FIRST YEAR—3

Carlson, Edwin N., Brainerd
Nelson, Ewart G., Kennedy
Plut, Frank J., Crosby

The Bulletin of the University of Minnesota

The School of Mines Announcement for the Year 1918-1919

Vol. XXI No. 13 June 22 1918

Entered at the post-office in Minneapolis as second-class matter Minneapolis, Minnesota

1918

JULY

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UNIVERSITY CALENDAR

1918-1919

1918			
September	11	Wednesday	Registration closes except for new students
September	11-18	Week	Fees payable except for new students
September	17-24	Week	Examination for removal of conditions and entrance examinations
September	23-24		Registration and payment of fees for new students
September	25	Wednesday	First semester begins
October	17	Thursday	Senate meeting, 4:00 p.m.
November	5	Tuesday	General Election Day; a holiday
November	27	Wednesday	Thanksgiving recess begins 9:00 p.m.
December	2	Monday	Thanksgiving recess ends 8:00 a.m.
December	21	Saturday	Christmas vacation begins 12 m.
1919			
January	2	Thursday	Christmas vacation ends 8:00 a.m.
January	20	Monday	Second semester registration closes except for new students
January	27	Monday	Final examinations begin
January	27	Monday	Payment of second semester fees closes except for new students
January	31		Registration and payment of fees for
February	1		new students
February	3	Monday	Second semester begins
February	12	Wednesday	Lincoln's Birthday; a holiday
February	20	Thursday	Senate meeting, 4:00 p.m.
February	22	Saturday	Washington's Birthday; a holiday
April	17	Thursday	Easter recess begins 9:00 p.m.
April	22	Tuesday	Easter recess ends 8:00 a.m.
April	22-28	Week	Condition examinations in certain colleges
May	15	Thursday	Senate meeting, 4:00 p.m.
May	23	Friday	Final examinations begin 2:00 p.m.
May	30	Friday	Memorial Day; a holiday
May	31	Saturday	Second semester closes
June	1	Sunday	Baccalaureate service
June	2	Monday	Senior Class Day exercises
June	4	Wednesday	Alumni Day
June	5	Thursday	Forty-seventh Annual Commencement
June	6	Friday	Summer vacation begins
June	16	Monday	Summer Session begins

The University year for 1919-20 will begin Tuesday, September 16. Classes will begin September 24.

Program of Supplementary Examinations

Tuesday,	Sept. 17	9-12 a.m.	Mechanics and Mathematics
		2-5 p.m.	Mining Engineering Subjects
Wednesday,	Sept. 18	9-12 a.m.	Chemistry
		2-5 p.m.	Drawing and Descriptive Geometry
		2-5 p.m.	Mechanical Engineering Subjects
Thursday,	Sept. 19	9-12 a.m.	Metallurgical Subjects
		2-5 p.m.	Physics
Friday,	Sept. 20	9-12 a.m.	Electrical Engineering Subjects
		2-5 p.m.	Geology and Mineralogy

THE SCHOOL OF MINES

FACULTY

MARION LEROY BURTON, Ph.D., D.D., LL.D., President 1005 S. E. 5th St.
CYRUS NORTHROP, LL.D., President Emeritus 519 10th Ave. S. E.
WILLIAM R. APPLEBY, M.A., Dean, and Professor of Metallurgy 928 S. E. 5th St.
JOHN R. ALLEN, M.E., Professor of Mechanical Engineering 2421 Girard Ave. S.
THOMAS M. BAINS, JR., E.M., Assistant Professor of Mining 1883 Iglehart Ave., St. Paul
WILLIAM E. BROOKE, B.C.E., M.A., Professor of Mathematics and Mechanics 416 S. E. Walnut St.
OSCAR C. BURKHARD, Ph.D., Assistant Professor of German 719 E. River Road
PETER CHRISTIANSON, B.S., E.M., Professor of Metallurgy 217 S. E. Union St.
ELTING H. COMSTOCK, M.S., Professor of Mine Plant and Mechanics 1319 S. E. 7th St.
JAMES DAVIES, Ph.D., Assistant Professor of German 3230 3rd Ave. S.
WILLIAM H. EMMONS, Ph.D., Professor of Geology and Mineralogy 1223 S. E. 7th St.
HENRY A. ERIKSON, Ph.D., Professor of Physics 424 S. E. Harvard St.
JOHN J. FLATHER, Ph.B., M.M.E., Professor of Mechanical Engineering 315 11th Ave. S. E.
*GEORGE B. FRANKFORTER, Ph.D., Professor of Chemistry 525 E. River Road
JULES T. FRELIN, B.A., Assistant Professor of Romance Languages 310 12th Ave. S. E.
ROBERT W. FRENCH, B.S., Assistant Professor of Drawing 1018 16th Ave. S. E.
FRANK F. GROUT, M.S., Associate Professor of Geology and Mineralogy 504 University Ave. S. E.
SAMUEL L. HOYT, E.M., Ph.D., Assistant Professor of Metallography 416 8th Ave. S. E.
A. WALFRED JOHNSTON, M.A., Assistant Professor of Geology 803 University Ave. S. E.
WILLIAM H. KIRCHNER, B.S., Professor of Drawing and Descriptive Geometry 722 10th Ave. S. E.
ALFRED E. KOENIG, M.A., Dr. Theol., Assistant Professor of German 602 S. E. 7th St.
SAMUEL KROESCH, Ph.D., Assistant Professor of German 611 S. E. Oak St.
EDWIN M. LAMBERT, M.E., Assistant Professor of Mine Plant and Mechanics 1086 12th Ave. S. E.

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* On leave of absence, 1918-19.

IRVILLE C. LECOMPTE, Ph.D., Professor of Romance Languages
827 University Ave. S. E.
FRANKLIN R. MCMILLAN, C.E., Assistant Professor of Structural Engineering 524 8th Ave. S. E.
ADOLPH F. MEYER, C.E., Associate Professor of Hydraulic Engineering
1467 Ashland Ave., St. Paul
JOHN F. MURPHY, Associate Professor of Mining 514 7th Ave. S. E.
WALTER R. MYERS, Ph.D., Assistant Professor of German
608 S. E. Oak St.
EVERETT W. OLMSTED, Ph.D., Professor of Romance Languages
2727 Lake of the Isles Blvd.
LEVI B. PEASE, M.S., Professor of Metallurgy 1070 16th Ave. S. E.
RUTH SHEPARD PHELPS, M.S., Assistant Professor of Romance Languages
East Sanford Hall
TERENCE T. QUIRKE, E.M., Ph.D., Assistant Professor of Geology
315 11th Ave. S. E.
FRANK B. ROWLEY, M.E., Assistant Professor of Experimental Engineering
217 S. E. Beacon St.
WILLIAM T. RYAN, E.E., Assistant Professor of Electrical Engineering
1827 Melbourne Ave. S. E.
CARL SCHLENKER, B.A., Professor of Romance Languages
514 11th Ave. S. E.
COLBERT SEARLES, Ph.D., Professor of Romance Languages
1941 Fremont Ave. S.
GEORGE D. SHEPARDSON, M.A., M.E., D.Sc., Professor of Electrical Engineering 717 E. River Road
*S. CARL SHIPLEY, B.S., M.E., Assistant Professor of Mechanical Engineering 1517 E. River Road
CHARLES F. SHOOP, B.S., Assistant Professor of Experimental Engineering
811 S. E. Fulton St.
CHARLES F. SIDENER, B.S., Professor of Chemistry 1320 S. E. 5th St.
CLINTON R. STAUFFER, Ph.D., Professor of Geology 1120 S. E. 5th St.
ANTHONY ZELENY, Ph.D., Professor of Physics 613 East River Road
THOMAS M. BRODERICK, Ph.D., Instructor in Geology 512 S. E. Delaware St.
FRANCIS B. BARTON, Ph.D., Assistant Professor of Romance Languages
507 S. E. Oak St.
WILLIAM E. BRYANT, Instructor in Foundry Practice 1108 S. E. 4th St.
ANDERS J. CARLSON, C.E., Instructor in Mine Plant and Mechanics
520 S. E. Delaware St.
*EDWARD W. DAVIS, B.S., Instructor in Mine Plant and Mechanics
979 14th Ave. S. E.
SOLOMON M. DELSON, Ph.B., Instructor in Romance Languages
517 9th Ave. S. E.
ELISE F. DEXTER, M.A., Instructor in German 314 10th Ave. S. E.
FRANCIS B. FOLEY, Assistant in Metallography 410 University Ave. S. E

* On leave of absence, 1918-19.

ISAAC W. GEIGER, Ph.D., Instructor in Chemistry 15 Barton Ave. S. E.
ARTHUR R. GRAVES, Ph.D., Instructor in German 407 S. E. 4th St.
FRANCIS A. HOBART, Instructor in Machine Shop Practice 512 S. E. Delaware St.
INGVALD KVITRUD, C.E., Instructor in Drawing 2001 S. 7th St.
MRS. BARBARA L. LUND, Ph.B., Assistant in Chemistry 600 S. E. Essex St.
LOUALLEN F. MILLER, B.S., M.A., Instructor in Physics 1112 S. E. 7th St.
AMOS F. MOYER, M.E., Instructor in Experimental Engineering 1624 LaFond St., St. Paul
*HOWARD D. MEYERS, B.S. in C.E., Instructor in Drawing 516 S. E. Oak St.
EDWARD P. QUIGLEY, Instructor in Forge Work 2923 Chicago Ave.
WILLIAM H. RICHARDS, Instructor in Carpentry 1423 W. 27th St.
ELWYN L. SMITH, B.S., Instructor in Metallurgy 1883 Iglehart Ave., St. Paul
WOLDEMAR M. STERNBERG, B.S., in Chem. Eng., Instructor in Chemistry 510 S. E. Ontario St.
GUSTAVE L. VAN ROOSBROECK, M.A., Instructor in Romance Languages 404½ 14th Ave. S. E.
H. LEE WARD, Ph.D., Instructor in Chemistry 2176 Scudder St., St. Paul
EDWIN H. ZEYDEL, M.A., Instructor in German 1312 S. E. 7th St.
ELIZABETH B. HENDERSON, Librarian 2618 Aldrich Ave. S.

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* On leave of absence, 1918-19.

GENERAL INFORMATION

The School of Mines was established by the Board of Regents in 1888, upon recommendation of the General Faculty of the University. The buildings and laboratories of the School are located on the main campus of the University. The mining districts of Minnesota are within a few hours, by rail, from Minneapolis. The heartiest coöperation exists between the various mine managements and the School, so that the mining properties are at all times open to parties from the school for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts. Students in the School of Mines have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

The School of Mines occupies the new building provided by the Legislature of 1913. In the basement are the assay and electro-metallurgical laboratories, together with machinery room, instrument room, balance room, furnace rooms, and necessary storerooms. On the first floor are the administrative offices, offices, and lecture rooms of the departments of Metallurgy and Mine Plant and Mechanics. On the second floor are the offices, lecture rooms, and drafting rooms of the department of Mining, the ore dressing laboratory, and the library of the School. On the third floor are the offices, laboratories, and lecture rooms of the department of Metallography, junior drafting room, photographic dark rooms, blue printing room, and offices and computing rooms for the branch of the Experiment Station serving the Tax Commission.

DEGREES

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M. (Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four or five years, and vice versa, provided such candidate completes an additional year's work at the School and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and Architecture, and in the School of Analytical and Applied Chemistry, who contemplate taking a degree in this School after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thoro courses in mechanics, mathematics, surveying, physics, chemistry, and the necessary theory and practice of structural, mechanical, and electrical engineering.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine if it has value for treatment. (d) *Mining Engineering*—to furnish material for treatment. (e) *Ore Testing*—to determine best methods of treatment. (f) *Ore Dressing*—furnishing products for metallurgical treatment. (g) *Metallurgy*—smelting and refining ores and ore dressing products; reduction to metals.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the state, to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the Tax Commission and to do such other work along the lines above outlined as may be requested by other state departments. Coöperation has been effected with the U. S. Bureau of Mines, the U. S. Geological Survey, the Minnesota Geological Survey, and the School of Chemistry.

The Experiment Station is prepared to assist citizens interested in these lines of work; to assay specimens of ore, rocks, clays, and minerals, found within the state, free of charge.

In submitting samples the sender must state the exact location where each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the office of the Station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, The University of Minnesota, Minneapolis, Minnesota.

LIBRARY

The library occupies a well-lighted room, 55 feet by 61 feet, on the second floor of the School of Mines building. The books have been carefully selected and form a working collection of great value, not only to the faculty and students, but also the mining men of the state. Only books relating to mining, metallurgy, metallography, geology, and allied subjects are shelved in this library, the general University library as well as the public libraries of Minneapolis and St. Paul serving as reserve collections. The library is especially rich in complete sets of periodicals, transactions, and the reports of state and foreign mining departments. Foreign technical literature is well represented. A card index is kept of all articles of value and interest appearing in the leading periodicals.

ADMISSION

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology), and Metallurgical Engineer may be completed in either four or five years. Students may enter the School of Mines without preparation in Higher Algebra and Solid Geometry. Such students must enter the five-year courses. It is recommended that students who come poorly prepared in Mathematics enter the five-year courses.

Students may be admitted to the School of Mines either by certificate or examination, or both.

ADMISSION BY EXAMINATION

Entrance examinations are offered at the University during registration week, September 17 to 20. Candidates entering by this method must pass examination in fifteen units so chosen as to satisfy the requirements outlined below. Certificates from the College Entrance Examination Board and from the High School Board are accepted in lieu of examinations in the subjects they represent. Those desiring to take examinations should notify the Registrar of the University in writing not later than August 15.

ADMISSION BY CERTIFICATE

Graduates of the following courses, provided their preparation satisfies the requirements outlined below, may be admitted.

1. Any four-year course of a Minnesota state high school or other accredited school in the state.

2. A four-year course of schools in any other state accredited to the state university of that state.

3. The Advanced Latin and Advanced English courses of the Minnesota state normal schools.

The applicant for admission should request the principal or superintendent to forward to the Registrar of the University a complete transcript of his high-school or preparatory-school record showing the number of weeks and hours per week spent upon each study, with the grades

entered as *passed, passed with credit,* or *passed with honor.* Credential blanks prepared by the University must be used; these blanks may be secured upon application to the Registrar. Upon receipt of the credentials at the University the Registrar will notify the applicant with regard to his admission.

ENTRANCE REQUIREMENTS

FIVE-YEAR COURSES

English, three units; Elementary Algebra and Plane Geometry, one unit each; ten additional units, of which not more than four may be in Group F.

FOUR-YEAR COURSES

Same as five-year courses with the addition of one-half unit each of Higher Algebra and Solid Geometry. It is recommended that students who enter these courses review Higher Algebra and Solid Geometry. Those unable to carry freshman mathematics satisfactorily will be required to re-register in the five-year course.

LIST OF ENTRANCE SUBJECTS

The term *unit* means not less than five recitations of forty minutes each per week for a period of thirty-six weeks. In manual subjects and kindred courses, it means the equivalent of ten recitation periods per week for thirty-six weeks.

Group A. English. Four units.

Group B. Languages. Latin, Greek, German, French, Spanish, Scandinavian, one to four units each.

Group C. History and Social Sciences. Ancient and Modern History, one unit each; English and Senior American History, one-half unit each; American Government, Economics, Economic History of England, and Economic History of the United States, one-half unit each; Commercial Geography, and History of Commerce, one-half or one unit each.

Group D. Mathematics. Elementary Algebra and Plane Geometry, one unit each; Higher Algebra, Solid Geometry, and Trigonometry, one-half unit each.

Group E. Natural Sciences. Physics and Chemistry, one unit each; Botany and Zoology, one-half or one unit each; Physiology, Astronomy, Geology, and Physiography, one-half unit each.

Group F. Vocational Subjects. Business Law and Business Arithmetic, one-half unit each; Elementary and Advanced Bookkeeping, one unit each; Stenography and Typewriting, one or two units. Freehand Drawing, Mechanical Drawing, and Shop Work, one or two units each. Agriculture, one to four units. Normal Training subjects, one to three

units, provided the applicant has had one year of subsequent teaching experience.

DESCRIPTION OF SUBJECTS ACCEPTED FOR ADMISSION

A description of the subjects accepted for admission to the University will be found in the Bulletin of General Information, which will be sent to any address upon application to the Registrar, The University of Minnesota, Minneapolis.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

ADMISSION TO ADVANCED STANDING

This University accepts records from all reputable colleges and universities for credit to advanced standing. Such records are accepted as far as they are equivalent to the work done in this institution. In bringing records from other institutions, the certificate must be upon the official blank of the institution granting the certificate and should show:

(a) The subject studied; if a language, the books read, etc.
(b) The number of weeks and hours per week spent upon each subject.
(c) Ground covered in laboratory work, in case of laboratory subjects.
(d) The result. The exact grades should be stated, accompanied by an explanation of the marking system employed.

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee of the School of Mines.

EXPENSES

One half of the Annual Incidental Fee of $55, which includes all laboratory charges, is payable at the opening of each semester. Cards entitling the student to admission to classes will not be issued until the fees have been paid. Books and supplies for each year of the course cost approximately $25. Field-work expense during the sophomore year is estimated at $150 and for the junior year at $225.

DEPOSIT FEE

At the beginning of each year, in addition to the first semester incidental fee, a deposit fee of five dollars is required of every student to cover the following items:

Change of registration..... $2.50
Examination for removal of condition at set time....$1.00 per subject

Rental of post-office box, University post-office (required of all) ..... $.50 per year
Locker rental, locker key deposit.....$.50 to $1.00 per year
Laboratory breakages, or damage to University property.
Penalties for late registration or late payment of fees.

A penalty fee of one dollar ($1) must be paid by all students who register or pay fees after the prescribed time. (See calendar, page 3.) After the day previous to that on which classes begin, the penalty for delay increases at the rate of twenty-five cents a day.

The unused balance of the deposit fee will be returned at the end of each year. If, at any time during the college year, the amount of charges against a student exceed the amount of the deposit, a second fee of five dollars ($5) will be required.

SPECIAL FEES

The following special items may be included in the expenses of a student:

Minnesota Union membership, required.....$1 a semester
Special examination for removal of condition, at other than the set time $5.00
Examination on subject taken out of class..... 5.00
No fee for such examinations on first entering the University, if taken within the first six weeks.
Military uniform, required of all freshmen and first-year students 15.00
Gymnasium suit 5.00
Health fee (per semester)..... 3.00

THE ELLIOT SCHOLARSHIP LOAN FUND

To fulfill the wish of the late Dr. A. F. Elliot to aid young men who find their efforts to obtain a practical education embarrassed through lack of means, the sum of $5,000 was placed in the hands of the Board of Regents as a scholarship fund. The income from this fund is loaned to students in the School of Mines on the following conditions: the financial needs of the applicant, his scholarship, moral character, enthusiasm shown in his work, and promise of usefulness in his profession. When money is available, it may be loaned to pay the expenses of worthy students during sickness. The loans are to be repaid, without interest, at the earliest convenience of the recipients.

GRADUATION

Students completing courses of study to the satisfaction of the faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University

before such degree shall be granted, and provided the examination in every case be held before a committee of the faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations held at the end of the second semester. Irregular attendance will debar a student from entering all final examinations.

THESIS

The thesis work is intended to bring in review and connect the work in Mining and Metallurgy, Geology and Mineralogy, Mechanical and Electrical Engineering, Mathematics and Mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of Field Work at the School of Mines, Tuesday, September 17, 1918, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the School.

SPECIAL NOTES

Students failing to receive a semester mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his average in all subjects and present himself for supplementary examinations, according to the program given on page 4.

Failure of the Registrar to notify a student of deficiencies will not be accepted as a reason for neglecting to report for necessary supplementary examinations. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

Students failing to receive a semester mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination at the end of the first or second semester will be given zero on the examinations.

Students whose absences in either semester exceed four weeks in the aggregate are not permitted to take examinations without special permission of the faculty.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

During the academic year students will be held responsible for the receipt of official communications sent to them through the University post-office. During the summer vacation they will be held responsible for the receipt of such communications sent to the home address given on registration blank for the preceding academic year, unless formal notification of their correct address is filed with the Registrar and the Dean.

COURSES OF STUDY

UNIFORM CURRICULUM TO END OF SOPHOMORE YEAR

The courses leading to the degrees of Engineer of Mines, Engineer of Mines in Geology, and Metallurgical Engineer, are uniform for the first three years of the five-year courses and for the first two years of the four-year courses.

Five-Year Courses

FIRST YEAR

First Semester

Chemistry 5*, General and Analytical, 5†
Mathematics 1, Algebra, 4
Mining 3, Mine Accounting, 6
Mechanical Engineering 1, Shop Work, 6
Mineralogy 23, Elements of Mineralogy, 8
Military Drill

Second Semester

Chemistry 6, General and Analytical 7, Chem. 5
Mathematics 2, Computation and Mensuration, 3
Mechanical Engineering 1, Shop Work, 6
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23
Military Drill

FRESHMAN YEAR

First Semester

Chemistry 11, Quantitative Analysis, 7, Chem. 5, 6
Drawing 11, Engineering Drawing, 10
Geology 105, Elements of Rock Study, 4, Mineral. 24
Mathematics 5, Algebra and Trigonometry, 6, Math. 1, 2
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Military Drill

Second Semester

Chemistry 12, Quantitative Analysis, 7, Chem. 11
Drawing 12, Engineering Drawing, 8, Draw. 11

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* Odd numbers indicate first-semester courses; even numbers, second-semester courses. A combination of the two (e.g., 5-6) indicates courses continuing through the year. In the case of courses repeated the second semester, the suffix *a* indicates first semester; the suffix *b*, second semester.

† Figure following the descriptive name of a course indicates number of hours a week. Course names following indicate prerequisite courses.

Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Geology 1b, General Geology, 3, Mineral. 24
Geology 106, Petrology, 4, Geol. 105
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Military Drill

SOPHOMORE YEAR

First Semester

Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Mathematics 7, Calculus, 5, Math. 6
Geology 73, Historical and Economic Geology, 3, Geol. 106
Metallurgy 105, Base Metals, 4, Met. 4
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1

Second Semester

Drawing 14, Drafting, 4, Draw. 13
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Field Work. Months of May, June, July, and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geol. 1b, 105, beginning about June 15
Underground Mining Work, beginning about July 1

Four-Year Courses

FRESHMAN YEAR

First Semester

Chemistry 5, General and Analytical, 5
Drawing 11, Engineering Drawing, 10
Mathematics 5, Algebra and Trigonometry, 6
Mineralogy 23, Elements of Mineralogy, 8
Military Drill

Second Semester

Chemistry 6, General and Analytical, 7, Chem. 5
Drawing 12, Engineering Drawing, 8, Draw. 11
Mathematics 6, Trigonometry and Analytical Geometry, 6, Math. 5
Metallurgy 2, Assaying, 12, Chem. 5, Mineral. 23
Mineralogy 24, Descriptive Mineralogy, 4, Mineral. 23
Military Drill

SOPHOMORE YEAR

First Semester

Chemistry 11, Quantitative Analysis, 7, Chem. 5, 6
Drawing 13, Descriptive Geometry, 2, Draw. 12, Math. 6
Geology 105, Elements of Rock Study, 4, Mineral. 24
Mathematics 7, Calculus, 5, Math. 6
Metallurgy 3, General and Iron, 3, Chem. 6, Met. 2
Mining 1, Mine Surveying, 3, Math. 6
Physics 1, General, 3, Math. 6
Physics 3, General Laboratory Practice, 2, with Physics 1
Military Drill

Second Semester

Chemistry 12, Quantitative Analysis, 7, Chem. 11
Drawing 14, Drafting, 4, Draw. 13
Geology 1b, General Geology, 3, Mineral. 24
Geology 106, Petrology, 4, Geol. 105
Mathematics 8, Calculus, 3, Math. 7
Metallurgy 4, Wrought Iron and Steel, 3, Met. 3
Mining 2, Mine Surveying, 3, Min. 1
Mining 6, 1
Physics 2, General, 3, Physics 1
Physics 4, General Laboratory Practice, 2, with Physics 2
Military Drill
Field Work. Months of May, June, July, and August
Mining 2f, Surveying, Min. 2, beginning about May 1
Geology 1f, Geol. 1b, 105, beginning about June 15
Underground Mining Work, beginning about July 1

COURSES IN MINING ENGINEERING

COURSES LEADING TO THE DEGREE OF E.M.

Five-Year Courses

JUNIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Experimental Engineering 102a, Elementary Laboratory, 4, with Mech. 11
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 5, Ore Dressing, 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 101b, Materials Testing Laboratory, 4, with Mech. 10
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 6, Ore Dressing 4, Met. 5
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about July 1

SENIOR YEAR

First Semester

Electrical Engineering 53, Electric Power, 5, Physics, 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Experimental Engineering 108, Experimental Laboratory, 4, Exp. Eng. 101b
Mechanics 16, Mine Plant Design, 10, Mech. 15
Metallurgy 8, Special Problems, 4, Met. 7
Mining 12, 5, Min. 11
Mining 14, Thesis, 12, Min. 13

Four-Year Courses

JUNIOR YEAR

First Semester

Experimental Engineering 102a, Elementary Laboratory, 4, with Mech. 11
Geology 73, Historical and Economic Geology, 3, Geol. 106, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 105, Base Metals, 4, Met. 4
Metallurgy 5, Ore Dressing, 4
Mining 9, 5, Min. 6

Second Semester

Experimental Engineering 101b, Materials Testing Laboratory, 4, with Mech. 10
Mechanics 10, 6, Mech. 9
Mechanics 12, Mine Plant, 6, Mech. 11
Metallurgy 6, Ore Dressing 4, Met. 5
Metallurgy 106, Precious Metals, 4, Met. 105
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Underground Mining Work, beginning about July 1

SENIOR YEAR

First Semester

Chemistry 25, Ore and Slag Analysis, 7, Chem. 12
Electrical Engineering 53, Electric Power, 5, Physics 3, 4
Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 13, Water Power, 5, Mech. 10
Mechanics 15, Engineering Construction, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 106, Min. 8
Mining 11, 5, Min. 10
Mining 13, Thesis, 2, Min. 10f

Second Semester

Experimental Engineering 108, Experimental Laboratory, 4, Exp. Eng. 101b
Geology 112, Problems in Ore Deposits, 4, Geol. 111
Metallurgy 8, Special Problems, 4, Met. 7
Mechanics 16, Mine Plant Design, 10, Mech. 15
Mining 12, 5, Min. 11
Mining 14, Thesis, 12, Min. 13

DEPARTMENT OF MINING ENGINEERING

The department is well supplied with samples of the smaller mine equipment, models, drawings, photographs, lantern slides, and mine maps. The lectures treat of prospecting, development, support of excavations, mining methods, mine administration, mining law, and the necessary allied subjects. The courses in Mining Engineering extend through the sophomore, junior, and senior years.

MINE SURVEYING

The work in surveying is given in the sophomore year and is designed solely for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi or Vermilion Range. The exact location will be announced in March of each year.

The students will be divided into squads of two to four. Each squad must provide itself with a 6-foot steel tape graduated to hundredths. The duration of the course will be seven weeks. Each student will be required to complete satisfactorily the following exercises and surveys:

1. Chaining and taping
2. Compass work
3. Adjustment and use of wye and dumpy levels
4. Adjustment of mining transit
5. Reading angles
6. Traverse with transit and steel tape
7. Azimuth traverse with stadia
8. Determination of meridian, latitude, and time by solar and stellar observations
9. Survey of mining claim according to the regulations of the U. S. Government
10. Measurement of earthwork
11. Laying out railroad tangents, curves, and crossings
12. Exercises in plane table work and geological surveying
13. The survey of a mine

A full equipment of surveying instruments of the latest and best makes is furnished to each squad for this work.

This is followed by a course in Mine Mapping during the second semester of the junior year.

Students who furnish satisfactory evidence of proficiency in this work may be given credit therefor. The department, however, reserves the right in any case to require such students to take a theoretical or a practical examination or both.

FIELD WORK IN MINING

Sophomore Year

After the close of the field work in Geology (last two weeks in June), members of the sophomore class are required to engage for six weeks in underground mining work on the Minnesota or Michigan iron ranges, for which they may receive wages.

Junior Year

Upon termination of the junior field work in Metallurgy (about May 15), the members of the junior class, who are candidates for the degree of Engineer of Mines, are required to devote two weeks to the study of mine plant and mine operation under the direction of the department. This work will be given in one of the leading western metal mining districts, exact location to be announced in April of each year. Thereafter, during the months of June, July, and August, the student is required to spend at least six weeks in actual underground mining work in the West, for which he may receive wages. The department will render all possible assistance in locating students in districts of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must in person submit this diary to the department on the date of the reopening of field work. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 17, 1918. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering Field Work in Mining and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned: Metallurgy, September 17 to 24, inclusive; Mining and Mine Plant, September 25 to October 1.

On October 1 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 1. These reports shall become the property of the School.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reasons, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

COURSES LEADING TO THE DEGREE OF E.M. (GEOLOGY)

JUNIOR YEAR

First Semester

Geology 73, Historical and Economic Geology 3, 106, 1b
Geology 151, Advanced General Geology, 3, 73
Geology 131, Advanced Petrology 5, 106, 1b
German 1 or 21, 6
or
French 1 or 3, 3
Metallurgy 155, Metallography 4
Mining 9, 5, Min. 6
Elective 6

Second Semester

Geology 124, Structural and Metamorphic Geology 3, 73
Geology 132, Advanced Petrology 5, 131
Geology 144, Construction and Interpretation of Geologic Maps 3, 111
Geology 150, Field Geology 8, 124
Geology 152, Advanced General Geology 3, 151
German 3 or 22, 6, German 1 or 21
or
French 1 or 3, 6
Metallurgy 156, Metallography 4, 155
Mining 10, 5, Min. 9
Mining 4, Mine Mapping 6, Min. 2f

SENIOR YEAR

First Semester

Geology 111, Ore Deposits 4, 73
Geology 11, Paleontology 3, 1b
Mining 11, 5, Min. 10
Thesis 2
Elective 12

Second Semester

Geology 112, Problems in Ore Deposits 4, 111
Geology 12, Paleontology 3, 11
Mining 12, 5, Min. 11
Thesis 4
Elective 9

FIELD WORK IN GEOLOGY

At the end of the sophomore year mining students are required to devote about three weeks to geologic mapping. This course usually comes after a seven weeks' course in surveying and the fields chosen are the Vermilion and Mesabi iron ranges of Minnesota. This work is intended to train the students in the interpretation of field relations and the preparation of geologic maps and cross sections.

The second field course in geology is required only of those students who are candidates for the E.M. in Geology degree. The course begins early in May and is completed in June. The course requires altogether about six weeks' work, and the field chosen is the Black Hills region of South Dakota or some other western region. The student is trained in the interpretation of field data; in detailed mapping, underground and on the surface; in the preparation of geologic cross sections through mines; and he may gather material which will serve as a basis for future study in advanced courses the following year. The work conforms with the standards of official surveys as nearly as practicable. At the close of the field season the students are expected to obtain positions with mining companies either as miners or as engineers, or if openings are available, they may enter geological surveys for the season's work.

COURSES IN METALLURGY

COURSES LEADING TO THE DEGREE OF MET.E.

Five-Year Courses

JUNIOR YEAR

First Semester

Geology 111, Ore Deposits, 4, Geol. 106
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 5, Ore Dressing, 4, Geol. 23 and 24
Metallurgy 13, Ore Dressing Lab. 4, Geol. 23 and 24
Metallurgy 153, Metallography 7, Chem. 12, Physics 1 and 2
Mining 9, 5, Min. 6

Second Semester

Geology 112, Problems in Ore Deposits, 4, Geol. 111
Mechanics 10, 6, Mech. 9
Mechanics 14, Met. Plant, 2, Mech. 11
Metallurgy 6, Ore Dressing, 4, Met. 5 and 13
Metallurgy 14, Ore Dressing, Lab. 4, Met. 5 and 13
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Practical work in mills and smelters beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering, 53, Electric Power, 5, Physics, 3, 4
Mechanics 13, Water Power, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 5, 6, 106
Metallurgy 11, Thesis, 8, Met. 106, Met. 5, 6, and 13
Metallurgy 109, Electrometallurgy, 8, Met. 3, 4, 105, and 106

Second Semester

Metallurgy 8, Special Problems, 8, Met. 7
Metallurgy 10, Advanced Metallurgy 10, Met. 7
Metallurgy 16, Thesis, 18, Met. 11

Four-Year Courses

JUNIOR YEAR

First Semester

Geology 73, Historical and Economic Geology, 3, Geol. 106, 1b
Mechanics 9, 5, Math. 8
Mechanics 11, Mine Plant, 5, Math. 8
Metallurgy 105, Base Metals, 5, Met. 4
Metallurgy 5, Ore Dressing, 4, Geol. 23 and 24
Metallurgy 13, Ore Dressing Lab. 4, Geol. 23 and 24
Metallurgy 153, Metallography 7, Chem. 12, Physics 1 and 2
Mining 9, 5, Min. 6

Second Semester

Mechanics 10, 6, Mech. 9
Mechanics 14, Met. Plant, 2, Mech. 11
Metallurgy 6, Ore Dressing, 4, Met. 5 and 13
Metallurgy 14, Ore Dressing, Lab. 4, Met. 5 and 13
Metallurgy 106, Precious Metals, 5, Met. 105
Metallurgy 154, Metallography 7, Met. 153
Mining 10, 5, Min. 9
Mining 4, Mine Mapping, 6, Min. 2f
Field Work. Months of May, June, July, and August
Metallurgy 6f, beginning about May 1
Mining 10f, beginning about May 15
Practical work in mills and smelters beginning about June 1

SENIOR YEAR

First Semester

Electrical Engineering, 53, Electric Power, 5, Physics, 3, 4
Geology 111, Ore Deposits, 4
Mechanics 13, Water Power, 5, Mech. 10
Metallurgy 7, Ore Testing, 10, Met. 5, 6, 106
Metallurgy 11, Thesis, 8, Met. 106, Met. 5, 6, and 13
Metallurgy 109, Electrometallurgy, 8, Met. 3, 4, 105, and 106

Second Semester

Geology 112, Problems in Ore Deposits, 4
Metallurgy 8, Special Problems, 8, Met. 7
Metallurgy 10, Advanced Metallurgy 10, Met. 7
Metallurgy 16, Thesis, 18, Met. 11

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal

methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in Metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags is shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their report in detail. This work is offered to students completing the necessary courses in Mineralogy and Chemistry.

ORE DRESSING

The lectures and recitations in Ore Dressing extend through the junior year, and comprise the detailed study of ore dressing and concentrating machinery, together with the study of typical combinations of dressing machines as found in the several mining districts of the United States. In connection with the theoretical work, the ore dressing laboratory and testing plant of the School is utilized for practical illustrations.

ORE TESTING

The lectures treat of the use and purposes of all the machinery connected with the subject, supplemented by detailed drawings. There are complete testing works, connected with the department where the student may see the working of, and handle for himself crushers, rolls, and concentrating machinery, as well as sizing apparatus and hydraulic separators. Sufficiently large amounts of ore are given to make the necessary tests upon the different machines and the students report the best method of treatment. The courses run through the senior year and are required of students both in Mining and Metallurgy.

The ore-testing works meet educational, as well as commercial, needs.

Educational.—The ore-testing plant acquaints the student with the construction and manipulation of the principal typical machines used in the leading ore-dressing establishments of the country. It is here that students in Mining and Metallurgical Engineering get the requisite practical experience. They handle all machines and operate on sufficiently large

amounts of material to determine the methods best suited to a given ore to extract the largest amount of metal with the least possible loss.

Commercial.—Ore-testing works are an important factor in mining and metallurgical projects. The commercial object is to determine the best method of treating a given ore so as to yield the largest percentage of the metal it contains at the least possible cost. Samples varying from 500 pounds to car-load lots can be treated by various methods.

As the funds appropriated for the erection of such a plant were sufficient to purchase only the necessary machinery, the business men of Minneapolis generously provided a suitable building. The building, 94 by 66 feet, is built of brick and stone.

FIELD WORK IN METALLURGY

At the end of the junior year students are required to study practical operations at one or more smelters and mills. This work will begin about May 1. Not over three weeks' time will be devoted to this work.

Upon termination of the junior field work in Metallurgy and one week in Mining (not later than June 1), the members of the junior class who are candidates for the Degree of Metallurgical Engineer, are required to spend at least six weeks in practical work in one or more of the smelters or mills, for which they may receive wages. The department will render all possible assistance in locating students in districts of their choice. Each student must keep a diary and record therein, in minute detail, all observations and sketches. He must, in person, submit this diary to the department on the date of reopening of field work at the School. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject note-books considered below standard.

Field work will reopen at the School of Mines, Tuesday, September 17, 1918. No senior will be registered after that date. Registration will cover Field Work, Electric Power, and Geology.

The final reports covering field work in Metallurgy and Mining must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: Metallurgy, September 17 to 24, inclusive; Mining and Mine Plant, September 25 to October 1.

On October 1 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 1. These reports shall become the property of the School.

METALLOGRAPHY

Courses in Metallography are offered to seniors who are candidates for the degree of Metallurgical Engineer, students in the Colleges of Science, Literature, and the Arts, Engineering, Chemistry, and the Graduate School.

These courses deal with the microscopic examination of metals, alloys, and ores. The lectures treat of and describe the apparatus used in connection with this subject, the methods of preparing specimens, the physical, chemical, and metallurgical principles involved, and the interpretation of the results of microscopic examination. A collection of specimens, microphotographs, and lantern slides covering wrought iron, low carbon, structural, rail, and tool steels, brasses, bronzes, and other industrial alloys are available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals, alloys, and ores. The laboratory is equipped with microscopes, electric and portable gas furnaces, and pyrometers of the latest and improved types. A special dark room is available for the preparation of microphotographs.

DEPARTMENTAL STATEMENTS

EXPLANATION OF COURSE NUMBERS

Odd numbers indicate first-semester courses; even numbers, second-semester courses. A combination of the two (e.g., 5-6) indicates courses continuing through the year. The suffixes *a* and *b* apply to one-semester courses offered both semesters, *a* indicating the first semester and *b* the second semester (e.g., 3a,b; 4a,b). The suffix *f* indicates summer field work.

All undergraduate courses are numbered from 1 to 100. All courses open to undergraduates and graduates are numbered from 101 to 200. Strictly graduate courses are numbered from 201 up.

CHEMISTRY

Professors George B. Frankforter, Charles F. Sidener; Instructors Woldemar M. Sternberg, Isaac W. Geiger, H. Lee Ward; Assistant Mrs. Barbara L. Lund.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
5.	Gen. & Anal. Chemistry.....	3	2	All fr.	..
6.	Gen. & Anal. Chemistry.....	1	6	All fr.	5
11.	Quantitative Analysis.....	1	6	All soph.	6
12.	Quantitative Analysis.....	1	6	All soph.	11
24.	Iron & Steel Analysis.....	1	6	Elective	12
25.	Ore & Slag Analysis.....	1	6	Elective	12
144.	Electrochemistry	1	4	Elective	12

5-6. General and Analytical Chemistry. An introduction to descriptive, physical, and metallurgical chemistry and qualitative analysis. Geiger and Assistants.

11-12. Quantitative Analysis. A general discussion of quantitative methods, with laboratory work in gravimetric analysis, first semester; followed by a discussion of standard solutions and the necessary stoichiometric calculations with laboratory work in volumetric analysis, second semester. Sidener, Sternberg.

24. Iron and Steel Analysis. Includes technical methods for the determination of the common constituents of iron ores, iron, and steel, with training in rapid work. Sidener, and Assistants.

25. Ore and Slag Analysis. Rapid technical method for the determination of certain constituents in ores and slags. Sidener.

144. Electrochemistry. A discussion of electro-analytical methods and industrial electrochemical processes, and their underlying principles. Ward.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor William H. Kirchner; Assistant Professor Robert W. French; Instructors Ingvald Kvitrud, Howard D. Myers.*

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11.	Engineering Drawing	..	10	All fr.	..
12.	Engineering Drawing	..	8	All fr.	11
13.	Descriptive Geometry	2	..	All soph.	12, Math. 6
14.	Drafting	..	4	All soph.	13

11. Engineering Drawing. Sketching, lettering, representation, including parallel and radial projection, elements of drafting, details of machines and structures, interpretation of working drawings. Kirchner, Kvitrud, Myers.

12. Engineering Drawing. Continuation of Course 11 as outlined above. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Maps and sketches. Brush and pen conventions. Kvitrud, Myers.

13. Descriptive Geometry. Projection; central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. Kirchner.

14. Drafting. Graphics, machine drafting, and structural drafting. Instruction in drafting room methods. French.

ELECTRICAL ENGINEERING

Professor George D. Shepardson; Assistant Professor William T. Ryan.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
53.	Electric Power	2	2	Sr. E. M. & Met. E.	Physics 3, 4

55. Electric Power. Elementary principles of continuous currents. Continuous current generators and motors. Elementary principles of alternating currents. Alternating current generators, transformers, and motors. Measurement of power. Elementary principles of transmission and distribution. Lectures, recitation, and laboratory work. Ryan.

* On leave of absence, 1918-19.

EXPERIMENTAL ENGINEERING

Professors JOHN R. ALLEN, WILLIAM E. BROOKE; Associate Professor ADOLPH F. MEYER; Assistant Professors FRANKLIN R. MCMILLAN,* FRANK B. ROWLEY, CHARLES F. SHOOP; Instructor AMOS F. MOYER.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
101a,b.	Materials Testing Lab....	..	4	Jr. E. M. & Met. E.	With Math. 11
102a,b.	Elementary Laboratory...	..	4	Jr. E. M. & Met. E.	With Math. 10
108.	Experimental Laboratory.	..	4	Sr. E. M. & Met. E.	21

101a,b. MATERIALS TESTING LABORATORY. Investigation of physical properties of metals and engineering materials: wood, cement, ropes, etc. supplemented by lectures on materials of construction and methods of testing. Mining and Metallurgical Engineers carry Course 101b for twelve weeks only. .....

102a,b. ELEMENTARY LABORATORY. Calibration of gages, pitot tube, indicator spring, thermometers, weir notches, etc., lubricants, steam calorimeters, valve setting, engine clearance. Tests of hoists, water motor, ram, pulsometer, steam and internal combustion engines. Tests of power pump. Boiler trial. .....

108. EXPERIMENTAL LABORATORY. (Twelve weeks' course.) Hydraulic measurements. Tests of water motors, rams, steam pumps, steam engines, and boilers. .....

GEOLOGY AND MINERALOGY

Professors WILLIAM H. EMMONS, CLINTON R. STAUFFER; Associate Professor FRANK F. GROUT; Assistant Professors A. WALFRED JOHNSTON, TERENCE T. QUIRKE; Instructor THOMAS M. BRODERICK.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1b.	General Geology	3	..	All soph.	24
1f.	Field Work	..	2 wks.	All soph.	1b and 105
11.	Paleontology	3	..	Sr. E. M. (Geol.)	1b
12.	Paleontology	3	..	Sr. E. M. (Geol.)	11
23.	Elements of Mineralogy....	4	4	All fr.	..
24.	Descriptive Mineralogy	2	2	All fr.	23
73.	Histor. & Econ. Geology...	3	..	All jr.	1b and 105
105.	Elements of Rock Study..	..	4	All soph.	24
106.	Petrology	..	4	All soph.	105
111.	Ore Deposits	4	..	Sr.E.M.&E.M.(Geol.)	106
112.	Problems in Ore Deposits..	..	4	Sr.E.M.&E.M.(Geol.)	111
124.	Struct. & Metamorph. Geol.	3	..	Jr. E. M. (Geol.)	73 and 105
131.	Advanced Petrology	2	3	Jr. E. M. (Geol.)	106, 1b

* On leave of absence, 1918-19.

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
132.	Advanced Petrology	2	3	Jr. E. M. (Geol.)	131
137.	Testing Econ. Minerals.....	1	4	Elective	24, 73
140.	Applied Petrology	1	4	Elective	See statement
144.	Construction & Interpretation of Geologic Maps...	..	4	Elective	73
150.	Field Geology	..	..	Jr. E. M. (Geol.)	124
151.	Advanced General Geology.	3	..	Jr. E. M. (Geol.)	73
152.	Advanced General Geology.	3	..	Jr. E. M. (Geol.)	151
246.	Pre-Cambrian Geology	3	3	Elective	124
247.	Geol. & Exploration of Lake Superior Region	3	..	Elective	124

1b. General Geology. A synoptical treatment of materials of the earth and of geologic processes. Physiographic, dynamic, and structural geology, with a brief introduction to Historical Geology. Johnston.

1f. Field Work. About two weeks in June are spent in geologic mapping of selected areas in the iron districts of Minnesota. Involves preparation of geologic maps, and written reports.

11. Paleontology. A study of fossil forms with special reference to those of geologic importance. Stauffer.

12. Paleontology. Faunas and their correlation. A continuation of Course 11. Stauffer.

23. Elements of Mineralogy. The crystal systems; morphological, physical, and chemical character of minerals; occurrence, genesis, and uses of minerals; classifications and description of common minerals. Determinative work in laboratory, blowpipe analysis, sight identification. Broderick, Grout.

24. Descriptive Mineralogy. A continuation of Course 23, special attention being given to metalliferous and rock-forming minerals. Laboratory determination and sight identification. The use of the goniometer and microscope. Laboratory work, reference reading, and field excursions. Broderick, Grout.

73. Historical and Economic Geology. (a) Historical Geology. Geologic history of North America, with special reference to its syngenetic mineral deposits. (b) Economic Geology. Study of non-metallic minerals of economic value, and discussions of geologic guides to prospecting for these deposits. Emmons, Quirke.

105. Elements of Rock Study. The occurrence and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. Broderick, Grout.

106. Petrology. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and

metamorphic rocks. The origin and classification of rocks. Broderick, Grout.

111. Ore Deposits. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. Emmons.

112. Problems in Ore Deposits. Field excursions, map work, lectures on field and laboratory methods. Emmons.

124. Structural and Metamorphic Geology. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. Johnston.

131-132. Advanced Petrology. Advanced optical methods. Criteria for rapid identification of minerals and rocks. The uses of schedules and tables. Standard rock types. Regional and genetic studies. Petrographic reports. Grout.

137. Testing Economic Minerals. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, oil, building stone, and metallic ores. Grout.

140. Applied Petrology. To follow or accompany Course 132. Determination of transparent and opaque ores and gangue minerals. Microscopic studies of paragenesis of ores and other mineral associations by means of reflecting light. Practical petrographic problems. Grout.

144. Construction and Interpretation of Geologic Maps. Hours to be arranged. Methods of geologic examination; problems in construction and interpretation of geologic maps and sections, with special reference to underground mapping of metalliferous areas. Quirke.

150. Field Geology. Detailed and systematic work conforming with standards of official surveys. Preparation of geologic maps, structure sections, and reports; a study of the paragenesis of ores and their relations to geologic structures. Field for 1917-18, Black Hills, South Dakota. Emmons, Johnston.

151. Advanced General Geology. Geologic processes and their results; development of the North American continent. Stauffer.

152. Advanced General Geology. A continuation of Course 151. Stauffer.

246. Pre-Cambrian Geology. The problems of pre-Cambrian correlation and structure; the pre-Cambrian stratigraphy of North America. Given in alternate years. Three credits. Not offered in 1917-18. Johnston.

247. Geology and Exploration of Lake Superior Region. The geology of the Lake Superior iron districts. Methods used in the exploration

of iron ore; interpretation of drill cores; cartographic expression of drill data; models of drilled areas. Principles of magnetic surveying. Three credits. JOHNSTON.

GERMAN

Professor CARL SCHLENKER; Assistant Professors OSCAR C. BURKHARD, JAMES DAVIES, ALFRED KOENIG, SAMUEL KROESCH, WALTER R. MYERS; Instructors ELISE F. DEXTER, ARTHUR R. GRAVES, EDWIN H. ZEYDEL.

COURSES

No.	Title	Rec. hrs.	Required of	Prerequisite courses
1a,b.	Beginning	6	Jr. E. M. (Geol.)	..
3a,b.	Intermediate	6	Jr. E. M. (Geol.)	1a,b.
5-6.	Prose and Poetry	6*	Elective	2 yrs. prep. German
11-12.	Rapid Reading	6*	Elective	3a or 3b
21-22.	Scientific Intermediate	6*	Elective	1-3 or equivalent
23-24.	Adv. Scientific Reading	6*	Elective	5-6 or 4 yrs. prep. Ger.

* Both semesters must be completed before credit is given for either semester.

1a,b. BEGINNING. Double course. Pronunciation, grammar, conversation, and composition; selected readings in easy prose and verse. KOENIG, KROESCH, MYERS.

3a,b. INTERMEDIATE. Double course. Selected texts in modern narrative and descriptive prose; selected lyrics and ballads; a drama of Lessing, Goethe, or Schiller. Assigned reading of texts outside of class. KOENIG, KROESCH, MYERS.

5-6. PROSE AND POETRY. Geography, history, and legend. Review of German grammar throughout the year. BURKHARD, DAVIES, GRAVES.

11-12. RAPID READING. First semester: narrative prose; Hauff, Storm, Sudermann. Second semester: Plays of Lessing, Goethe, Schiller, Hebbel. Assigned readings and reports. DAVIES, GRAVES.

21-22. SCIENTIFIC INTERMEDIATE. This course aims to give students a reading knowledge of German for use in scientific studies. GRAVES.

23-24. ADVANCED SCIENTIFIC READING. Reading of monographs and periodicals. Not open to those who have credit for Course 7-8. May be supplemented by Course 20-30. .....

MECHANICAL ENGINEERING

Professor JOHN J. FLATHER; Assistant Professor S. CARL SHIPLEY; Instructors FRANCIS A. HOBART, EDWARD QUIGLEY, WILLIAM H. RICHARDS, WILLIAM E. BRYANT.

COURSES

No.	Title	Lab. hrs.	Required of	Prereq. courses
1a.	Pattern Making	6 (9 wks.)	1st-yr. E. M. & Met. E.	..
1b.	Foundry	6 (9 wks.)	1st-yr. E. M. & Met. E.	..
1c.	Forge	6 (9 wks.)	1st-yr. E. M. & Met. E.	..
1d.	Machine & Bench work	6 (9 wks.)	1st-yr. E. M. & Met. E.	..

1a. Pattern Making. Use of tools, lathe and bench work, making of timber joints, core boxes, and flasks. Richards.

1b. Foundry. Molding, core making, mixing and casting metals. Bryant.

1c. Forge. Use of tools, forging, welding, tool dressings and tempering. Quigley.

1d. Machine and Bench Work. Use of tools and elementary machine operations. Shipley, Hobart.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Assistant Professor Samuel L. Hoyt; Instructor Elwyn L. Smith; Assistant Francis B. Foley.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
2.	Assaying	4	8	All fr.	Chem. 5, Mineral, 23
3.	Gen. Met. & Iron & Steel.	3	..	Soph. E. M. & Met. E.	2, Chem. 6
4.	Wrought Iron & Steel	3	..	Soph. E. M. & Met. E.	3
5.	Ore Dressing	4	..	All jr.	..
6.	Ore Dressing	4	..	All jr.	..
6f.	Field Work in Metallurgy.	..	10 days	Jr. E. M. & Met. E.	Satisfactory completion of jr. year
7.	Ore Testing	2	8	Sr. E. M. & Met. E.	106, 5
8.	Special Problems in Ore Testing	..	4	Sr. E. M. & Met. E.	7
10.	Advanced Metallurgy	2	8	Sr. Met. E.	7
11.	Thesis in Metallurgy	..	8	Sr. Met. E.	106, 5
13.	Ore Dressing Lab.	..	4	Jr. Met. E.	Geol. 23 & 24
14.	Ore Dressing Lab.	..	4	Jr. Met. E.	5 & 13
16.	Thesis & Specifications.	..	18	Sr. Met. E.	11
105.	Met. of Base Metals	4	..	Jr. E. M. & Met. E.	4
106.	Met. of Precious Metals.	4	..	Jr. E. M. & Met. E.	105
109.	Electrometallurgy	3	..	Sr. Met. E.	2, 4, 105, 106
153.	Metallography	3	4	Jr. Met. E.	Chem. 12, Phys. 1 & 2
154.	Metallography	3	4	Jr. Met. E.	Met. 153
157.	Metallog. for Engineers.	3	4	Elective	Mech. Eng. 3 & 4
158.	Adv. Met. for Engineers.	3	4	Elective	Met. 157
160.	Metallog. for Chemists.	2	2	Elective	Chem. 12
161.	Dental Metallography	3	..	Elective	..
163.	Advanced Metallog.	To be ar.		Elective	Met. 154
164.	Advanced Metallog.	To be ar.		Elective	..

2. Assaying. Determination of values of ores, metallurgical products, and bullion. Appleby and Assistants.

3. General Metallurgy and Metallurgy of Iron. Including the subjects of combustion, fuels, refractory materials, and furnaces. Lectures and recitations on metallurgy of iron. Christianson.

4. Metallurgy of Wrought Iron and Steel. Puddling and hearth processes for the production of wrought iron. Cementation, crucible, Bessemer and open hearth processes for the production of steel. General principles and construction of furnaces. Christianson.

5-6. Ore Dressing. Examination of ores, crushing, sizing classification, and methods of mechanical separation. Smith.

6f. Field Work in Metallurgy. Study of metallurgical operations at smelters and mills. Detailed report is required covering plants visited. Christianson, Pease.

7. Ore Testing. Determinations of methods of ore treatment, stamping, concentration, cyanidation, roasting, amalgamation, and flotation. Christianson and Assistants.

8. Special Problems in Ore Testing. Continuation of Course 7. Assay of mill and smelter products so as to regulate smelting charges and roasting operations. Pease and Assistants.

10. Advanced Metallurgy. Pyrometry, calorimetry, metallurgical calculations to determine heat distribution and heat balance. Christianson.

11. Special Problems in Metallurgy. Research work preparatory to thesis. Appleby and Assistants.

13-14. Ore Dressing Laboratory. Practical problems in crushing, sizing, classification, and concentration of minerals. Smith.

16. Thesis and Specifications. Detailed investigations of ore treatment, with report including designs and specifications for suitable plants. Appleby and Assistants.

105. Metallurgy of the Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining methods. Pease.

109. Electrometallurgy. Application of electricity to production of heat for smelting ores and refining metals. Costs of fuel and electricity for heating, relative efficiencies of electric and fuel furnaces. Construction of high temperature furnaces and commercial plants. Christianson.

153-154. Metallography. Theory of metallic alloys. Metallographic technique. Properties of metals and alloys. Metallography of iron and steel and commercial alloys. Technical metallography. Hoyt.

157. Metallography for Chemical Students. The preparation of metallic alloys; their microscopical and thermal analysis. Steel and other commercial alloys with particular reference to chemical metallurgy. Corrosion of steel and non-ferrous alloys. Metallography applied to analytical chemistry. Hoyt.

161. Dental Metallography. Study of the dental alloys from the standpoint of metallography. Hoyt.

163-164. Advanced Metallography. Technical and scientific research. The study of steel rails, automobile and locomotive parts, tool steels, etc. Special problems in metallography with outside reading. Seminar work on the recent advances in metallography. Hoyt.

MINE PLANT AND MECHANICS

Professor Elting H. Comstock; Assistant Professor Edwin M. Lambert; Instructors Anders J. Carlson, Edward W. Davis.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Algebra	3	..	All 1st-yr. students	..
2.	Computation & Mensuration.	3	..	All 1st-yr. students	..
5.	Algebra & Trigonometry.....	6	..	All fr.	1 & 2
6.	Spherical Trig. & Anal. Geom.	6	..	All fr.	5
7.	Calculus	5	..	All soph.	6
8.	Calculus	3	..	All soph.	7
9.	Mechanics	5	..	All jr.	8
10.	Mechanics	6	..	All jr.	9
11.	Mine Plant	5	..	Jr. E. M. & Met. E.	8
12.	Mine Plant	6	..	Jr. E. M.	11
13.	Hydraulics & Water-Power..	5	..	All sr.	10
14.	Metallurgical Power Plant...	2	..	Jr. Met. E.	11
15.	Engineering Construction ...	1	4	Sr. E. M. & Met. E.	10
16.	Mine Plant Design.....	..	10	Sr. E. M.	15
18.	Mill and Smelter Design....	..	6	Sr. Met. E.	15

1. Algebra. Equations with one or more unknown quantities, inequalities, involution and evolution, theory of exponents, surds, quadratic equations, numerical and literal, equations with unknown quantities that can be solved by means of quadratic equations, progressions. Carlson.

2. Computation and Mensuration. Demonstrations of most important theorems of solid geometry. Volumes, approximate volumes, prismoidal formula, etc. Approximate computation, graphs, and graphical computation, logarithms and logarithmic computation, areas and approximations of areas, use of slide rule. Carlson.

5. Algebra and Trigonometry. Functions, functional notation, factor and remainder theorems, factors and values of functions, determinants, development of functions, theory of equations, permutations and combinations; trigonometric ratios, right triangles, definitions of trigo-

nometric functions, analytic relations, trigonometric equations, etc. COMSTOCK.

6. SPHERICAL TRIGONOMETRY AND ANALYTICAL GEOMETRY. Solution of spherical triangles; systems of coördinates, loci, equations and properties of straight line, transformation of coördinates, equations and properties of conics, equations of second degree, higher plane curves, space coördinates, point, plane, quadric surfaces, etc. COMSTOCK.

7. CALCULUS. Nature of differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, indeterminate forms, partial derivatives, change of variable. CARLSON.

8. CALCULUS. Elementary integration, undetermined coefficients, rational fractions, rationalization, formulas of reduction, hyperbolic functions, some differential equations of mechanics. CARLSON.

9. MECHANICS. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy; elementary mechanics of materials. LAMBERT.

10. MECHANICS. Mechanical and elastic properties of materials of construction; beams, shafts, columns, reinforced concrete, hollow cylinders and spheres, rollers, plates; theory of internal stress. LAMBERT.

11-12. MINE PLANT. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. COMSTOCK.

13. HYDRAULICS AND WATER-POWER. Laws of the equilibrium, pressure, and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, speed control, power-house equipment, transmission. CARLSON.

14. METALLURGICAL PLANT. Power, air, and water supply for metallurgical plants. COMSTOCK.

15. ENGINEERING CONSTRUCTION. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures, design of mining structures. LAMBERT.

16. MINE PLANT DESIGN. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. COMSTOCK.

18. MILL AND SMELTER DESIGN. A study of the construction and mechanical equipment of mills and smelters in connection with thesis work. COMSTOCK.

MINING

Associate Professor JOHN F. MURPHY; Assistant Professor THOMAS M. BAINS, JR.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	Mine Surveying	3	..	All soph.	Math. 6
2.	Mine Surveying	3	..	All soph.	1
2f.	Field Work	..	7 wks.	All soph.	2
3.	Mine Accounting	..	6	All 1st-yr. students	..
4.	Mine Mapping	..	6	All jr.	2f
6.	Mining	1	..	All soph.	..
9.	Mining	5	..	All jr.	6
10.	Mining	5	..	All jr.	9
10f.	Practical Mining	..	2 wks.	All jr.	Satisfactory completion of jr. yr.
11.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	10
12.	Mining	5	..	Sr. E. M. & E. M. (Geol.)	11
13.	Thesis	..	2	Sr. E. M.	10f
14.	Thesis	..	12	Sr. E. M.	13

2f. FIELD WORK. Practice in general surveying during the month of May. Practice in underground surveying during the first three weeks of June. This work is given on the Iron Ranges. CARLSON, LAMBERT.

3. ELEMENTARY MINE ACCOUNTING. Elementary accounting in general; applications to mine accounts; primary records, labor, supply, mine and mill products, and fund sheets; secondary records, invoice, labor and supply, mine and mill cost sheets, trial balance. BAINS.

4. MINE MAPPING. Mine mapping in accordance with prevalent practice in the western mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. CARLSON.

6. MINING. Introductory course in mining. MURPHY.

9. MINING. Occurrence of ore bodies, prospecting, churn and diamond drilling, drilling, blasting, excavation, tunneling and drifting. BAINS.

10. MINING. Shaft sinking, underground mining methods, support of underground excavation. MURPHY.

10f. PRACTICAL MINING. Study of mining operations. Mine plant and equipment and practical mining work; a mine to be selected by department during months of May, June, July, and August. COMSTOCK, MURPHY, and Assistants.

11. MINING. Open pit mining, quarrying, coal mining, mining alluvial deposits. MURPHY.

12. Mining. Drainage, transportation, ventilation, mine sanitation and hygiene, mine examination, mine management, mining law, economics of mining. Bains.

13, 14. Thesis. Conference. Design and specifications of mining details required in thesis study. Bains, Murphy.

PHYSICS

Professors Henry A. Erikson, Anthony Zelney; Instructor Louallen F. Miller.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1.	General Physics	3	..	All soph.	Math. 6
2.	General Physics	3	..	All soph.	1
3.	General Lab. Practice	..	2	All soph.	With 1
4.	General Lab. Practice	..	2	All soph.	With 2

1. General Physics. Mechanics, heat, and sound. Treatment of such fundamental principles and problems as will best serve mining or metallurgical engineers in practical work, and develop investigative insight necessary for the solution of mining and metallurgical problems. Miller.

2. General Physics. Electricity, magnetism, and light, as stated under Course 1. Theory illustrated by practical applications. Enough of light given to understand optical instruments of mining and metallurgy, and comprehend optical principles of crystal structure in crystallography. Miller.

3. General Laboratory Practice. Measurements in mechanics and heat. Intended to develop accuracy, method, system, and experimental control. Miller.

4. General Laboratory Practice. Measurements in electricity, magnetism, and light. The experiments in light being largely supplementary to the purposes stated in Course 2. Miller.

ROMANCE LANGUAGES

Professors Everett Ward Olmsted, Irville C. Le Compte, Colbert Searles; Assistant Professors Francis B. Barton, Jules T. Frelin, Ruth S. Phelps; Instructors Solomon M. Delson, Gustave van Roosbroeck.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
1b.	Beginning French	6	Jr. E. M. (Geol.)	..
3b.	Intermediate French	6	Jr. or sr. E. M. (Geol.)	1b
5.	Survey French Lit.	3	Sr. E. M. (Geol.)	3b
6.	Survey French Lit.	3	Sr. E. M. (Geol.)	5

1b. Beginning French. Stress on accurate pronunciation, reading, reading vocabulary, and the essentials of grammar. Daily oral and written exercises (dictation and reproduction in French). Searles, Barton, Delson, Frelin, van Roosbroeck.

3b. Intermediate. French grammar, composition, and reading; increased use of French in the classroom. Selections from modern prose and poetry. Le Compte, Barton, Delson, Frelin, van Roosbroeck.

5-6. General Survey of French Literature. Lectures, recitations, and assigned readings. Designed to cover the whole period in historical outline. Selections from representative authors. Le Compte, Barton, Phelps, van Roosbroeck.

STUDENTS

SENIORS—15

Allard, Raymond W., St. Paul
Armstrong, Harold K., Minneapolis
Cowin, Percy G., Minneapolis
Dowdell, Ralph L., St. Paul
Foley, Lyndon L., Minneapolis
Gannett, Roger W., Minneapolis
Hsieh, Chung, Kirin, China
Ingersoll, Guy E., Hibbing
Jerrard, Walter L., St. Cloud
Kwong, Yih Kum, Shanghai, China
Lee, Liang, Hunan, China
Moga, John A., St. Paul
Nichols, Clifford R., Buhl
Quinn, Howard E., Melrose
Strand, Harry W., Marine Mills

JUNIORS—13

Abramson, Jake, Minneapolis
Barr, J. Carroll, Jr., Pittsburgh, Pa.
Berg, Locksley D., Minneapolis
Donaghue, Abner J., Minneapolis
Flom, Frank, Minneapolis
Frellsen, Sidney A., Minneapolis
Goldberg, Bert, St. Paul
Goldberg, Samuel B., St. Paul
Hosted, Joseph O., Duluth
Mellem, Walter R., St. Paul
Miao, Yun Tai, Yunnan, China
Rockwell, Seass A., Fargo, N. D.
Sullivan, Dan C., Stillwater

SOPHOMORES—17

Arnold, Lewis E., Minneapolis
Chadbourn, Charles H., Minneapolis
Davies, Herman F., Minneapolis
Johnsen, Trygve, St. Paul
Johnson, Axel L., Benson
Johnston, Kenneth A., St. Paul
Kersten, Erwin H. W., Minneapolis
Kirkpatrick, Roscoe C., Champlin
Mark, Israel C., Minneapolis
Mars, William P., Duluth
Munson, Arthur M., St. Paul
Olson, Paul W., Warren
Peterson, Clarence D., Minneapolis
Powers, Sheldon M., Minneapolis
Raiter, Clifford R., Minneapolis
Rydlun, Edwyn G., Minneapolis
Wheeler, James D., Minneapolis

FRESHMEN—20

Butler, Roy G., St. Paul
Carlson, Edwin N., Brainerd
Dawson, Loren W., Minneapolis
Henkel, Howard, Minneapolis
Hope, Lawrence I., Minneapolis
Leigh, Ralph E., Lakefield
Le Roy, James J., Alexandria
Lucas, John J., Minneapolis
Nicholls, William J., Jr., Ely
Orear, Benjamin F., Minneapolis
Patten, Richard C., Minneapolis
Ryan, Milton A., Duluth
Sebenius, Carl H., Duluth
Sebenius, William H. M., Duluth
Strange, Howard E., Duluth
Walz, Clarence M., Gladstone, Mich.
West, Herbert S., Minneapolis
Welshons, Mervyn, Stillwater
Yaeger, William H., Valley City, N. D.
Zanger, Eugene, Minneapolis

FIRST YEAR—6

Anderson, Oscar B., Crosby
Barker, Clifton R., Excelsior
Friedl, Arthur, St. Paul
Kubias, Ralph L., Minneapolis
Swartz, Sam, Minneapolis
Swenson, Clifford H., Minneapolis

UNIVERSITY CALENDAR

1919-1920

1919			
September	20	Saturday	Payment of fees closes, except for new students
September	23	Tuesday	Juniors and seniors, School of Mines, report for completion of field work.
September	26-30	Week	Examinations for removal of conditions and entrance examinations
September	29-30		Registration days
October	1	Wednesday	Fall quarter begins
October	16	Thursday	Senate meeting, 4:00 p.m.
November	27	Thursday	Thanksgiving Day; a holiday
December	18	Thursday	Senate meeting, 4:00 p.m.
December	23	Tuesday	Christmas vacation begins 9:00 p.m.
1920			
January	2	Friday	Christmas vacation ends 8:30 a.m.
January	2	Friday	Winter quarter begins
February	12	Thursday	Lincoln's Birthday; a holiday
February	19	Thursday	Senate meeting, 4:00 p.m.
March	25	Thursday	Winter quarter ends
April	1	Thursday	Spring quarter begins
April	2	Friday	Good Friday; a holiday
May	1	Saturday	Field work for sophomores and juniors in School of Mines begins
May	20	Thursday	Senate meeting, 4:00 p.m.
June	13	Sunday	Baccalaureate service
June	16	Wednesday	Spring quarter closes
June	17	Thursday	Forty-eighth Annual Commencement
June	18-19		Registration days for summer quarter
June	21	Monday	Summer quarter begins
September	3	Friday	Summer quarter ends

Program of Supplementary Examinations

Friday,	Sept. 26	9-12 a.m.	Physics
		2-5 p.m.	Chemistry, Experimental Engineering
Saturday,	Sept. 27	9-12 a.m.	Mathematics and Mechanics
		2-5 p.m.	Drawing and Descriptive Geometry
Monday,	Sept. 29	9-12 a.m.	Metallurgical subjects
		2-5 p.m.	Electrical and Mechanical Engineering subjects, Mine Plant and Surveying
Tuesday,	Sept. 30	9-12 a.m.	Geology and Mineralogy
		2-5 p.m.	Mining subjects

THE SCHOOL OF MINES

FACULTY

Marion LeRoy Burton, Ph.D., D.D., LL.D., President
Cyrus Northrop, LL.D., President Emeritus
William R. Appleby, M.A., Dean, and Professor of Metallurgy
John R. Allen, M.E., Professor of Mechanical Engineering
Thomas M. Bains, Jr., E.M., Associate Professor of Mining
Francis B. Barton, Ph.D., Assistant Professor of Romance Languages
Frank W. Bliss, M.S., Assistant Professor of Chemistry
William E. Brooke, B.C.E., M.A., Professor of Mathematics and Mechanics
Oscar C. Burkhard, Ph.D., Assistant Professor of German
Anders J. Carlson, C.E., Assistant Professor of Mine Plant and Mechanics
Peter Christianson, B.S., E.M., Professor of Metallurgy
Elting H. Comstock, M.S., Professor of Mine Plant and Mechanics
James Davies, Ph.D., Assistant Professor of German
William H. Emmons, Ph.D., Professor of Geology and Mineralogy
Henry A. Erikson, Ph.D., Professor of Physics
Jules T. Frelin, B.A., Assistant Professor of Romance Languages
Robert W. French, B.S., Assistant Professor of Drawing
Isaac W. Geiger, Ph.D., Assistant Professor of Chemistry
Frank F. Grout, M.S., Associate Professor of Geology and Mineralogy
William F. Holman, Ph.D., Assistant Professor of Mathematics and Mechanics
Samuel L. Hoyt, E.M., Ph.D., Associate Professor of Metallography
A. Walfred Johnston, M.A., Assistant Professor of Geology
Lauder W. Jones, Ph.D., Professor of Chemistry
William H. Kirchner, B.S., Professor of Drawing and Descriptive Geometry
Alfred E. Koenig, M.A., Dr. Theol., Assistant Professor of German
Samuel Kroesch, Ph.D., Assistant Professor of German
Edwin M. Lambert, M.E., Associate Professor of Mining Engineering
Irville C. LeCompte, Ph.D., Professor of Romance Languages
Louallen F. Miller, B.S., M.A., Professorial Lecturer in Physics
Walter R. Myers, Ph.D., Assistant Professor of German
Everett W. Olmsted, Ph.D., Professor of Romance Languages
Levi B. Pease, M.S., Professor of Metallurgy
Ruth Shepard Phelps, M.S., Assistant Professor of Romance Languages
Terence T. Quirke, E.M., Ph.D., Assistant Professor of Geology
Frank B. Rowley, M.E., Assistant Professor of Experimental Engineering
William T. Ryan, E.E., Assistant Professor of Electrical Engineering
Carl Schlenker, B.A., Professor of German
Colbert Searles, Ph.D., Professor of Romance Languages

George D. Shepardson, M.A., M.E., D.Sc., Professor of Electrical Engineering
Charles F. Shoop, B.S., Assistant Professor of Experimental Engineering
Charles F. Sidener, B.S., Professor of Chemistry
M. Cannon Sneed, Associate Professor of Chemistry
Clinton R. Stauffer, Ph.D., Professor of Geology
Anthony Zeleny, Ph.D., Professor of Physics
Leon Archibald, C.E., Instructor in Drawing and Descriptive Geometry
Thomas M. Broderick, Ph.D., Instructor in Geology
Ralph L. Dowdell, Met.E., Instructor in Metallography
Amos F. Moyer, M.E., Instructor in Experimental Engineering
*Howard D. Myers, B.S. in C.E., Instructor in Drawing
James C. Sanderson, Ph.D., Instructor in Mine Plant and Mechanics
Elwyn L. Smith, B.S., Instructor in Metallurgy
Elizabeth B. Henderson, Librarian

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* On leave of absence, 1919-20.

GENERAL INFORMATION

The School of Mines was established by the Board of Regents in 1888, upon recommendation of the general Faculty of the University. The buildings and laboratories of the School are located on the main campus of the University. The mining districts of Minnesota are within a few hours, by rail, from Minneapolis. The heartiest coöperation exists between the various mine managements and the School, so that the mining properties are at all times open to parties from the School for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts. Students in the School of Mines have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

The School of Mines occupies the new building provided by the Legislature of 1913. In the basement are the assay and electro-metallurgical laboratories, together with machinery room, instrument room, balance room, furnace rooms, and necessary storerooms. On the first floor are the administrative offices, offices and lecture rooms of the Departments of Metallurgy and Mine Plant and Mechanics. On the second floor are the offices, lecture rooms, and drafting rooms of the Department of Mining, the ore-dressing laboratory, and the library of the School. On the third floor are the offices, laboratories, and lecture rooms of the Department of Metallography, the Department of Mining Engineering, junior drafting room, photographic dark rooms, blue-printing room, and offices and computing rooms for the branch of the Experiment Station serving the Tax Commission.

DEGREES

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M. (Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four years, and vice versa, provided such candidate completes an additional year's work at the School and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and Architecture, and in the School of Analytical and Applied Chemistry, who contemplate taking a degree in this School after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thoro courses in mechanics, mathematics, surveying, physics, chemistry, and the necessary theory and practice of structural, mechanical, and electrical engineering.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine if it has value for treatment. (d) *Mining Engineering*—to furnish material for treatment. (e) *Ore Testing*—to determine best methods of treatment. (f) *Ore Dressing*—furnishing products for metallurgical treatment. (g) *Metallurgy*—smelting and refining ores and ore dressing products; reduction to metals.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the state, to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the Tax Commission, and to do such other work along the lines above outlined as may be requested by other state departments. Coöperation has been effected with the U. S. Bureau of Mines, the U. S. Geological Survey, the Minnesota Geological Survey, and the School of Chemistry.

The Experiment Station is prepared to assist citizens interested in these lines of work; to assay specimens of ore, rocks, clays, and minerals, found within the state, free of charge.

In submitting samples the sender must state the exact location where each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the office of the Station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, The University of Minnesota, Minneapolis, Minnesota.

ADMISSION

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology), and Metallurgical Engineer may be completed in four years.

Freshmen will be divided into two sections as follows:

A. Those entering with credits in higher algebra and solid geometry.

B. Those entering without credits in higher algebra and solid geometry. Students in Section B will carry a special course in mathematics during their freshman year.

Details as to admission and entrance requirements, description of subjects accepted for admission, and list of fees and expenses will be found in the Bulletin of General Information, which will be sent to any address upon application to the Registrar, the University of Minnesota, Minneapolis.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

ADMISSION TO ADVANCED STANDING

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee of the School of Mines.

GRADUATION

Students completing courses of study to the satisfaction of the Faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examinations in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least one full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the Faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examinations for the third quarter. Irregular attendance will debar a student from entering all final examinations.

THESIS

The thesis work is intended to bring in review and connect the work in Mining and Metallurgy, Geology and Mineralogy, Mechanical and Electrical Engineering, Mathematics and Mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in

mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of Field Work at the School of Mines, Tuesday, September 23, 1919, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the School.

SPECIAL NOTES

Students failing to receive a quarter mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the Registrar his average in all subjects and present himself for supplementary examinations, according to the program on page 3.

Failure of the Registrar to notify a student of deficiencies will not be accepted as a reason for neglecting to report for necessary supplementary examinations. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

Students failing to receive a quarter mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The Faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination for any quarter will be given zero on the examinations.

Students whose absences in any quarter exceed 20 per cent of the scheduled class hours will not be permitted to take examinations without special permission of the Faculty.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

During the academic year students will be held responsible for the receipt of official communications sent to them through the University post-office. During the summer vacation they will be held responsible for the receipt of such communications sent to the home address given on registration blank for the preceding academic year, unless formal notification of their correct address is filed with the Registrar and the Dean.

COURSES OF STUDY

UNIFORM CURRICULUM TO END OF SOPHOMORE YEAR

The courses leading to the degrees of Engineer of Mines, Engineer of Mines in Geology, and Metallurgical Engineer are uniform for the first two years.

Freshmen will be divided into two sections as follows:

A. Those entering with credits in advanced algebra and solid geometry.

B. Those entering without credits in advanced algebra and solid geometry.

Subjects with the prefix A are to be taken by freshmen in section A; those with the prefix B are to be taken by freshmen in section B; and those without prefix are to be taken by students of both sections.

FRESHMAN YEAR

First Quarter

Chemistry 1f*, General Inorganic, 7†
Drawing 11f, Engineering Drawing, 10
A. Mathematics 2f, Algebra, 6
B. Mathematics 1f, Algebra and Solid Geometry, 6
Mineralogy 23f, Elements of Mineralogy, 8
Military Drill

Second Quarter

Chemistry 2w, General Inorganic, 7, Chem. 1f
Drawing 12w, Engineering Drawing, 8, Draw. 11f
Mathematics 4w, Trigonometry, 6
Metallurgy 1w, Assaying, 4, Chem. 1f, Mineral. 23f
Metallurgy 2w, Assaying Laboratory, 8, Chem. 1f, Mineral. 23f
Mineralogy 24w, Elements of Mineralogy, 4
Military Drill

Third Quarter

Chemistry 3s, General Inorganic, 7, Chem. 2w
Drawing 13s, Engineering Drawing, 8, Draw. 12w
Mathematics 5s, Analytical Geometry, 6, Math. 4w
B. Mathematics 3s, Algebra, 4, Math. 1f
Mineralogy 25s, Elements of Mineralogy, 8
Military Drill

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* The suffixes f, w, or s, after the course number indicate the quarter in which a course is offered—fall, winter, or spring quarter respectively. Two or three suffixes indicate that a course is offered in each of the corresponding quarters.

† Figure following the descriptive name of a course indicates number of hours per week. Course names following indicate prerequisite courses.

SOPHOMORE YEAR

First Quarter

Chemistry 11f, Qualitative Analysis, 7, Chem. 3s
Drawing 14f, Descriptive Geometry, 3, Draw. 13s, Math. 5s
Geology 105f, Rock Study, 4, Geol. 25s
Mathematics 6f, Calculus, 4, Math. 5s
Metallurgy 3f, General, 3, Met. 1w, 2w, Chem. 3s
Mining Engineering 1f, Mine Surveying, 3, Math. 4w
Physics 1f, General, 3, Math. 5s
Physics 2f, General Lab. Practice, 2, Math. 5s
Military Drill

Second Quarter

Chemistry 20w, Quantitative Analysis, 8, Chem. 11f
Drawing 15w, Drafting, 4, Draw. 14f
Geology 1w, General, 3, Geol. 125f
Geology 106w, Petrography 4, Geol. 105f
Mathematics 7w, Calculus, 3, Math. 6f
Metallurgy 4w, Met. of Pig Iron, 3, Met. 3f
Mining Engineering 2w, Mine Surveying, 3, Min. Eng. 1f
Physics 3w, General, 3, Phys. 1f
Physics 4w, General Lab. Practice, 2, Phys. 1f
Military Drill

Third Quarter

Geology 2s, General, 7, Geol. 105f
Mathematics 8s, Calculus, 6, Math. 7w
Metallurgy 5s, Wrought Iron and Steel, 3, Met. 4w
Mining 1s, Introductory Mining, 4
Mining Engineering 3s, Mine Surveying, 3, Min. Eng. 2w
Physics 5s, General, 3, Phys. 3w
Physics 6s, General Lab. Practice, 2, Phys. 3w
Military Drill
Mining Engineering 4s, Field Work beginning about May 1, 7 weeks, Min. Eng. 3s
Geology 85, Field Work beginning about June 20, 2 weeks, Geol. 2s
Underground Mining Work beginning about July 5

JUNIOR AND SENIOR YEARS

COURSES LEADING TO THE DEGREE OF E.M.

JUNIOR YEAR

First Quarter

Experimental Engineering, M.E. 83.4f, Elementary Lab. 4, with Mech. 12f
Geology 73f, Economic, 3, Geol. 2s, 105f
Mechanics 9f, Mechanics, 5, Math. 8s
Mechanics 12f, Mine Plant, 6, Math. 8s

Metallurgy 105f, Base Metals, 4, Met. 3f
Metallurgy 12f, Ore Dressing, 3, Phys. 5s, Geol. 25s
Mining 2f, Exploration, 5, Mining 1s
Mining 6f, First Aid, 1 week

Second Quarter

Experimental Engineering, M. & M. 43.2w, Materials Testing Lab., 4, with Mech. 10w
Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mechanics 13w, Mine Plant, 6, Mech. 12f
Metallurgy 106w, Base Metals, 4, Met. 105f
Metallurgy 13w, Ore Dressing, 3, Phys. 5s, Geol. 25s
Mining 3w, Tunneling, 5, Mining 2f
Mining Engineering 5w, Mine Mapping, 6, Min. Eng. 4s

Third Quarter

Mechanics 11s, Mechanics of Materials, 5, Mech. 10w
Mechanics 14s, Mine Plant, 6, Mech. 13w
Metallurgy 107s, Precious Metals, 4, Met. 106w
Metallurgy 17s, Ore-Dressing Lab., 6, Phys. 5s, Geol. 25s
Mining 4s, Mining Methods, 5, Mining 3w
Mining Engineering 6s, Mine Mapping, 6, Min. Eng. 5w
Metallurgy 21s, Field Work in Metallurgy beginning about May 1, 10 days, satisfactory completion of junior year
Mining 5s, Field Work in Mine Plant and Mining beginning about May 10, 2 weeks, satisfactory completion of junior year

SENIOR YEAR

First Quarter

Electrical Engineering 144.21f, Electric Power, 5, Phys. 5s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Mechanics 17f, Water Power, 7, Mech. 9f
Mechanics 18f, Engineering Construction, 8, Mech. 11s
Metallurgy 6f, Ore Testing, 2, Met. 107s
Metallurgy 7f, Ore-Testing Lab., 8, Met. 107s
Mining 52f, Mining Reports, 5, Mining 4s
Mining 55f, Thesis, 2, Mining 4s
Mining 51f, Mine Rescue, 1 week

Second Quarter

Experimental Engineering, M.E. 184.1w, Experimental Lab. 4, Exp. Eng. M.E. 83.4f
Geology 112w, Advanced Economic, 3, Geol. 111f
Geology 80w, Advanced Historical, 3, Geol. 73f
Mechanics 19w, Mine Plant Design, 9, Mech. 18f
Metallurgy 8w, Special Problems, 4, Met. 107s
Mining 53w, Mining Problems, 5, Mining 52f
Mining 56w, Thesis, 12, Mining 55f

Third Quarter

Geology 113s, Problems in Ore Deposits, 4, Geol. 112w
Mechanics 20s, Mine Plant Design, 12, Mech. 19w
Metallurgy 9s, Special Problems, 8, Met. 107s
Mining 54s, Mining Law, 5, Mining 53w
Mining 57s, Thesis, 12, Mining 56w

DEPARTMENT OF MINING

The Department is well supplied with samples of the smaller mine equipment, models, drawings, photographs, lantern slides, and mine maps. The lectures treat of prospecting, development, support of excavations, mining methods, mine administration, mining law, and the necessary allied subjects. The courses in mining extend through the sophomore, junior, and senior years.

FIELD WORK IN MINING

JUNIOR YEAR

At the end of the junior year students are required to study mine plant and mining methods in one or more mining districts under the direction of members of the Faculty. This work begins about May 1, and not over three weeks will be devoted to it. The work is carried on in the leading western metal mining districts, the exact location to be announced in April of each year. The expenses for the trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover board and lodging and necessary side trips. Any balance will be returned at the close of the work in the field. During the months of June, July, and August, the student is urged to spend at least six weeks in actual underground mining work in the West, for which he may receive wages. The Department will render all possible assistance in locating students in districts of their choice. Each student must keep a notebook containing a record of all observation and necessary detail sketches. These notebooks will be collected at the close of the trip and returned to the student at the reopening of field work at the School. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below the standard that should be demanded of candidates for senior work.

Field work will reopen at the School of Mines, Tuesday, September 23, 1919. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in Mining and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned: Metallurgy, September 23 to 30, inclusive; Mining and Mine Plant, October 1 to 14 inclusive.

On October 14 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a

typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 14. These reports shall become the property of the School.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the Department. Should a student, for sufficient reasons, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

DEPARTMENT OF MINING ENGINEERING

MINE SURVEYING

The work in surveying is given in the sophomore year and is designed primarily for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi, Cuyuna, or Vermilion Range. The exact location will be announced in March of each year. The expenses for this trip are estimated at $150.

The students will be divided into squads of two to four. Each student will be required to complete satisfactorily a practical course in plane and underground surveying including exercises in chaining and taping; adjustment and use of surveying instruments; solar and stellar observations; laying out railroad tangents and curves; making earthwork estimates; and other problems. In addition each squad will be required to make a yardage estimate of the stripping of an open-pit mine; to transfer a meridian, from the surface, underground and make a complete survey of an underground mine.

The data obtained will be used in the course in Mine Mapping during the winter quarter of the junior year.

A full equipment of surveying instruments of the latest and best types is furnished each squad for this work.

Courses Leading to the Degree of E.M. (Geology)

JUNIOR YEAR

First Quarter

Geology 61f or 65f, Physical Mineralogy or Crystallography, 6, Mineralogy 25s
Geology 73f, Economic, 3, Geol. 2s, 105f
Geology 131f, Advanced Petrology, 6, Geol. 2s, 106w
Geology 151f, Advanced General, 3, Geol. 73f

German 1f or 21f, or French 4f or 10f, or Spanish 34f or 40f, 5 or 3
Mining 2f, Exploration, 5, Min. 1s
Electives, 9
Mining 6f, First Aid, 1 week

Second Quarter

Geology 124w, Struct. and Metamorphic, 3, Geol. 73f, 105f
Geology 132w, Advanced Petrology, 6, Geol. 2s, 106w
Geology 144w, Geologic Maps, 6, Geol. 73f
Geology 152w, Advanced General, 3, Geol. 73f
German 2w or 22w, or French 5w or 11w, or Spanish 35w or 41w, 5 or 3
Mining 3w, Tunneling, 5, Min. 2f
Mining Engineering 5w, Mine Mapping, 6, Min. Eng. 4s
Electives, 3

Third Quarter

Geology 125s, Struct. and Metamorphic, 3, Geol. 73f, 105f
Geology 133s, Advanced Petrology, 6, Geol. 2s, 106w
Geology 145s, Geologic Maps, 6, Geol. 73f
Geology 153s, Advanced General, 3, Geol. 73f
Mining 4s, Mining Methods, 5, Min. 3w
Electives, 3

Geology 150s, Field Work in Geology beginning about May 1, six weeks, Geol. 125s

Geologic Field Work beginning about June 15 with geological surveys or private companies

SENIOR YEAR

First Quarter

Geology 11f, Paleontology, 3, Geol. 2s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Mining 52f, Mining Reports, 5, Min. 4s
*Metallurgy 12f, Ore Dressing, 3, Phys. 5s, Geol. 25s
Thesis, 8
Electives, 9
Mining 51f, Mine Rescue, 1 week

Second Quarter

Geology 12w, Paleontology, 3, Geol. 2s
Geology 137w, Testing Economic Materials, 5, Geol. 73f
140w, Applied Petrography, 5, Geol. 111f, 13s
Geology 166w, Mineralography, 6, Geol. 111f
*Metallurgy 13w, Ore Dressing, 3, Phys. 5s, Geol. 25s
Mining 53f, Mining Problems, 5, Min. 52f
Thesis, 3
Electives, 3

Third Quarter

Geology 13s, Paleontology, 3, Geol. 2s
Geology 113s, Problems in Ore Deposits, 4, Geol. 112w
Geology 141s, Applied Petrography, 5, Geol. 111f, 13s
Geology 167s, Mineralography, 6, Geol. 111f
*Metallurgy 17s, Ore-Dressing Lab., 6, Phys. 5s, Geol. 25s
Mining 54s, Mining Law, 5, Min. 53w
Thesis, 10

FIELD WORK IN GEOLOGY

At the end of the sophomore year mining students are required to devote about three weeks to geologic mapping. This course usually comes after a seven weeks' course in surveying and the fields chosen are the Vermilion and Mesabi iron ranges of Minnesota. This work is intended to train the students in the interpretation of field relations and the preparation of geologic maps and cross sections.

The second field course in geology is required only of those students who are candidates for the E.M. in Geology degree. The course begins early in May and is completed in June. The course requires altogether about six weeks' work, and the field chosen is the Black Hills region of South Dakota or some other western region. The student is trained in the interpretation of field data; in detailed mapping, underground and on the surface; in the preparation of geologic cross sections through mines; and he may gather material which will serve as a basis for future study in advanced courses the following year. The work conforms with the standards of official surveys as nearly as practicable. At the close of the field season the students are expected to obtain positions with mining companies either as miners or as engineers, or if openings are available, they may enter geological surveys for the season's work.

Field work in geology for students having taken either of the above trips will reopen at the School of Mines, Tuesday, September 23, 1919. The final reports covering the field work must be prepared at the School of Mines under the direct supervision of the Department of Geology. These reports are to be turned in to the Department on September 30.

Courses Leading to the Degree of Met.E.

JUNIOR YEAR

First Quarter

Geology 73f, Economic, 3, Geol. 2s, 105f
Mechanics 9f, Mechanics, 5, Math. 8s
Mechanics 12f, Mine Plant, 6, Math. 8s
Metallurgy 12f, Ore Dressing, 3, Phys. 5s, Geol. 25s
Metallurgy 14f, Ore-Dressing Lab., 4, Phys. 5s, Geol. 25s
Metallurgy 105f, Base Metals, 4, Met. 3f

* Advanced Quantitative Chemistry may replace Ore Dressing.

Metallurgy 153f, Metallography, 7, Chem. 20w, Phys. 5s
Mining 2f, Exploration, 5, Min. 1s
Mining 6f, First Aid, 1 week

Second Quarter

Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mechanics 13w, Mine Plant, 6, Mech. 12f
Metallurgy 13w, Ore Dressing, 3, Phys. 5s, Geol. 25s
Metallurgy 15w, Ore-Dressing Lab. 4, Phys. 5s, Geol. 25s
Metallurgy 106w, Base Metals, 4, Met. 105f
Metallurgy 154w, Metallography, 7, Met. 153f
Mining 3w, Tunneling, 5, Min. 5f
Mining Engineering, 5w, Mine Mapping, 6, Min. Eng. 4s

Third Quarter

Mechanics 11s, Mechanics of Materials, 5, Mech. 10w
Mechanics 14s, Mine Plant, 6, Mech. 13w
Metallurgy 16s, Ore-Dressing Lab., 6, Phys. 5s, Geol. 25s
Metallurgy 107s, Precious Metals, 4, Met. 106w
Metallurgy 155s, Metallography, 7, Met. 154w
Mining 4s, Mining Methods, 5, Min. 3w
Mining Engineering 6s, Mine Mapping, 6, Min. Eng. 5w
Metallurgy 21s, Field Work in Metallurgy beginning about May 1, 10 days, satisfactory completion of junior year
Mining 5s, Field Work in Mine Plant and Mining beginning about May 10, 2 weeks, satisfactory completion of junior year

SENIOR YEAR

First Quarter

Electrical Engineering 144.21f, Electric Power, 5, Phys. 5s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Mechanics 17f, Water Power, 7, Mech. 9f
Metallurgy 6f, Ore Testing, 2, Met. 107s
Metallurgy 7f, Ore-Testing Lab., 8, Met. 107s
Metallurgy 108f, Electrometallurgy, 3, Met. 107s
Metallurgy 18f, Thesis, 8

Second Quarter

Geology 80w, Advanced Historical, 3, Geol. 73f
Geology 112w, Advanced Economic, 3, Geol. 111f
Metallurgy 8w, Special Problems in Ore Testing, 4, Met. 107s
Metallurgy 10w, Advanced Metallurgy, 10, Met. 107s
Metallurgy 19w, Thesis, 18, Met. 18f

Third Quarter

Geology 113s, Problems in Ore Deposits, 4, Geol. 112w
Metallurgy 9s, Special Problems in Ore Testing, 4, Met. 107s

Metallurgy 11s, Advanced Metallurgy, 10, Met. 107s
Metallurgy 20s, Thesis, 18, Met. 19w

DEPARTMENT OF METALLURGY

This Department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags is shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their report in detail. This work is offered to students completing the necessary courses in mineralogy and chemistry.

ORE DRESSING

The lectures and recitations in Ore Dressing extend through the junior year, and comprise a detail study of ore dressing and concentrating machinery, together with a study of typical combinations of dressing machines as found in the various mining districts of the United States. In connection with the theoretical work, the ore-dressing laboratory and testing plant of the School is utilized for illustrations, and practical use of ore dressing machinery.

ORE TESTING

The lectures treat of the problems in ore testing such as extraction and losses in roasting, concentration and other milling operations. Both the ore-dressing laboratory and the Mines Experiment Station laboratory are available for working out practical problems. The Mines Experiment Station laboratory is the old Ore-Testing Works modified to aid the

mining interests of the State of Minnesota in solving problems connected with concentration and conservation of the iron and manganiferous ores of the state.

The School of Mines laboratories therefore serve both educational and commercial needs.

Educational.—The student becomes familiar with the use of the various types of machines such as crushers, rolls, classifiers, concentration and flotation machinery.

Commercial.—The laboratories are used by the Mines Experiment Station to determine best methods of treatment to produce a commercial product at the lowest cost. Recently additional commercial machinery has been obtained and new appliances are constantly being developed. Commercial samples varying from 500 pounds to car-load lots can be treated by various methods.

FIELD WORK IN METALLURGY

At the end of the junior year students are required to study practical operations at one or more smelters and mills. This work will begin about May 1. The expenses for this trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover board and lodging and necessary side trips. Any balance will be returned at the close of the work in the field.

Each student must keep a notebook containing a record of all observations and necessary detail sketches. These notebooks will be collected at the close of the trip and returned to the student at the reopening of field work at the School. In judging the character of the student's field work equal importance will be given to the completed report and to the original field notes. The Department reserves the right to reject notebooks considered below standard.

Upon termination of the junior field work in Metallurgy and two weeks in Mining and Mine Plant (not later than June 1), the members of the junior class who are candidates for the Degree of Metallurgical Engineer are urged to spend at least six weeks in practical work in one or more of the smelters or mills, for which they may receive wages. The Department will render all possible assistance in locating students in districts of their choice.

Field work will reopen at the School of Mines, Tuesday, September 23, 1919. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in Metallurgy and Mining must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: Metallurgy, September 23 to 30, inclusive; Mining and Mine Plant, October 1 to October 14, inclusive.

On October 14, all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings to scale,

made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 14. These reports shall become the property of the School.

METALLOGRAPHY

Courses in Metallography are offered to seniors who are candidates for the degree of Metallurgical Engineer, students in the Colleges of Science, Literature, and the Arts, Engineering, the School of Chemistry, and the Graduate School.

These courses deal with the microscopic examination of metals, alloys, and ores. The lectures treat of and describe the apparatus used in connection with this subject, the methods of preparing specimens, the physical, chemical, and metallurgical principles involved, and the interpretation of the results of microscopic examination. A collection of specimens, microphotographs, and lantern slides covering wrought iron, low carbon, structural, rail, and tool steels, brasses, bronzes, and other industrial alloys are available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals, alloys, and ores. The laboratory is equipped with microscopes, electric and portable gas furnaces, and pyrometers of the latest and improved types. A special dark room is available for the preparation of microphotographs.

DEPARTMENTAL STATEMENTS

EXPLANATION OF COURSE NUMBERS

The suffixes f, w, or s, indicate the quarter in which a course is offered, e.g., fall, winter, or spring quarters respectively. More than one suffix indicates that a course is offered in each of the corresponding quarters. No suffix indicates that the time of taking a course is to be arranged with the departments concerned.

All undergraduate courses are numbered from 1 to 100. All courses open to undergraduates and graduates are numbered from 101 to 200. Strictly graduate courses are numbered from 201 up.

CHEMISTRY

Professors Lauder W. Jones, Charles F. Sidener; Associate Professor M. Cannon Sneed; Assistant Professors Frank W. Bliss, Isaac W. Geiger.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	General Inorg. Chemistry.....	3	4	All fr.	....
2w	General Inorg. Chemistry.....	3	4	All fr.	1f
3s	General Inorg. Chemistry.....	3	4	All fr.	2w
11f	Qualitative Chem. Analysis.....	3	4	All soph.	3s
20w	Quantitative Chem. Analysis.....	1	7	All soph.	11f
23f	Iron and Steel Analysis.....	1	6	Elective	20w
24f	Mineral and Ore Analysis.....	1	6	Elective	20w

1f. General Inorganic Chemistry. A beginning course in chemistry. A study of the general laws of chemistry and of the non-metals and their compounds.

2w. General Inorganic Chemistry. A continuation of Course 1f.

3s. General Inorganic Chemistry. A study of the metals and their compounds. A continuation of Course 2w.

11f. Qualitative Chemical Analysis. Laboratory work in systematic qualitative analysis with lectures on solution, ionization, chemical and physical equilibrium, oxidation and reduction, and other subjects pertinent to qualitative analysis. Bliss.

20w. Quantitative Chemical Analysis. An introductory course covering the general principles and methods of quantitative analysis, both gravimetric and volumetric. Typical problems will be assigned and attention given to proper laboratory practice. Sidener, Geiger, and Assistants.

23f. Iron and Steel Analysis. The rapid technical methods for the determination of the common constituents of iron ore. Iron and steel

will be discussed and compared, and typical problems assigned for laboratory practice. SIDENER, GEIGER, and Assistants.

24f. MINERAL AND ORE ANALYSIS. A course in the rapid technical methods for the determination of important constituents in minerals, ores and slags. SIDENER, GEIGER, and Assistants.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor WILLIAM H. KIRCHNER; Assistant Professor ROBERT W. FRENCH; Instructors LEON ARCHIBALD, HOWARD D. MYERS.*

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11f	Engineering Drawing	0	10	All fr.	....
12w	Engineering Drawing	0	8	All fr.	11f
13s	Engineering Drawing	0	8	All fr.	12w
14f	Descriptive Geometry	3	0	All soph.	13s, Math. 5s
15w	Drafting	0	4	All soph.	14f

11f. ENGINEERING DRAWING. Sketching, lettering, representation, elements of drafting, details of machines and structures, interpretation of working drawings. KIRCHNER, FRENCH, ARCHIBALD.

12w. ENGINEERING DRAWING. Continuation of Course 11f. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. KIRCHNER, ARCHIBALD.

13s. ENGINEERING DRAWING. Continuation of Course 12w. The elements of general drafting. Maps and sketches. Brush and pen conventions. KIRCHNER, ARCHIBALD.

14f. DESCRIPTIVE GEOMETRY. Projection; central and special cases, principles and applications, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. KIRCHNER.

15w. DRAFTING. Graphics, machine drafting, and structural drafting. Instruction in drafting room methods. FRENCH, ARCHIBALD.

ELECTRICAL ENGINEERING

Professor GEORGE D. SHEPARDSON; Assistant Professor WILLIAM T. RYAN.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
144.21f	Electric Power	2	3	Sr. E.M.	Physics 5s

* On leave of absence, 1919-1920.

144.21f. Electric Power. Elementary principles of continuous currents. Continuous current generators and motors. Elementary principles of alternating currents. Alternating current generators, transformers, and motors. Measurement of power. Elementary principles of transmission and distribution. Lectures, recitation, laboratory work. Ryan.

EXPERIMENTAL ENGINEERING

Professors John R. Allen, William E. Brooke; Assistant Professors William F. Holman, Frank B. Rowley, Charles F. Shoop; Instructor Amos F. Moyer.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
M.E. 83.4f	Elementary Laboratory...	..	4	Jr. E.M.	With Mech. 12f
M.&M. 43.2w	Materials Testing Lab...	..	4	Jr. E.M.	With Mech. 10w
M.E. 184.1w	Experimental Laboratory	..	4	Sr. E.M.	Exp. Eng. M.E. 83.4f

M.E.83.4f. Elementary Laboratory. Calibrations of thermometer, gages, weirs, nozzle orifices, and meters. Efficiency of machines, friction of belting, friction tests, burning point, chill point, viscosity and specific gravity of oils. Tests of water motor, rams, and pulsometers.

M.&M.43.2w. Materials Testing Laboratory. Investigation of physical properties of metals and engineering materials: wood, cement, ropes, etc., supplemented by lectures on materials of construction and methods of testing. Brooke, Holman.

M.E.184.1w. Experimental Laboratory. Indicator practice, valve setting, separating and throttling calorimeter, tests of steam engine, gas engine, pump, air compressor, turbine, boiler, and power plant. Rowley, Shoop.

GEOLOGY AND MINERALOGY

Professors William H. Emmons, Clinton R. Stauffer; Associate Professor Frank F. Grout; Assistant Professors A. Walfred Johnston, Terence T. Quirke; Instructor Thomas M. Broderick.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1w	General Geology	3	..	All soph.	105f
2s	General Geology	3	4	All soph.	105f
11f	Paleontology	3	..	Sr.E.M.(Geol.)	2s
12w	Paleontology	3	..	Sr.E.M.(Geol.)	2s
13s	Paleontology	3	..	Sr.E.M.(Geol.)	2s
18w	Elem. of Paleontology.....	3	..	Elective	....
19s	Elem. of Paleontology.....	3	..	Elective	....

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
23f	Elem. of Mineralogy	4	4	All fr.	....
24w	Elem. of Mineralogy	2	2	All fr.	....
25s	Elem. of Mineralogy	4	4	All fr.	....
61f	Physical Mineralogy	2	4	Elective	25s
65f	Crystallography	2	4	Elective	25s
73f	Econ. Geology	3	..	All jr.	2s, 105f
80w	Advanced Hist. Geology	3	..	Sr.E.M.	73f
85	Summer Field Work	..	2 wks.	All soph.	2s
105f	Elem. of Rock Study	..	4	All soph.	25s
106w	Petrography	..	4	All soph.	105f
111f	Ore Deposits	3	..	Sr.E.M.&E.M.(Geol.)	73f, 106w
112w	Advanced Econ. Geology	3	..	Sr.E.M.&E.M.(Geol.)	111f
113s	Problems in Ore Deposits	..	4	Sr.E.M.&E.M.(Geol.)	112w
124w	Struct. & Metamorph. Geol.	3	..	Jr.E.M.(Geol.)	73f, 105f
125s	Struct. & Metamorph. Geol.	3	..	Jr.E.M.(Geol.)	73f, 105f
131f	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
132w	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
133s	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
137w	Testing Econ. Minerals	1	4	Sr.E.M.(Geol.)	73f
140w	Applied Petrography	1	4	Sr.E.M.(Geol.)	111f, 13s
141s	Applied Petrography	1	4	Sr.E.M.(Geol.)	111f, 13s
144w	Construction & Interpretation of Geologic Maps	..	6	Jr.E.M.(Geol.)	73f
145s	Construction & Interpretation of Geologic Maps	..	6	Jr.E.M.(Geol.)	73f
150s	Field Geology	..	..	Jr.E.M.(Geol.)	125s
151f	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
152w	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
153s	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
166w	Mineralography	..	6	Sr.E.M.(Geol.)	111f
167s	Mineralography	..	6	Sr.E.M.(Geol.)	111f
246	Pre-Cambrian Geology	3	3	Elective	125s
247	Geol. & Exploration of Lake Superior region	3	..	Elective	125s

1w, 2s. GENERAL GEOLOGY. A synoptical treatment of materials of the earth, and of geologic processes. Physiographic, dynamic, structural, and historical geology. JOHNSTON.

11f, 12w, 13s. PALEONTOLOGY. A study of fossil forms with special reference to those of geologic importance; faunas and their correlation. STAUFFER.

18w, 19s. ELEMENTS OF PALEONTOLOGY. An introduction to the study of fossil organisms. Lectures supplemented by field excursions. STAUFFER.

23f, 24w, 25s. ELEMENTS OF MINERALOGY. The crystal systems; morphological, physical, chemical characters of minerals; occurrence, genesis, and uses of minerals; classifications and description of common minerals; rock minerals, and common rocks. Determinative work in the laboratory, blowpipe analysis, sight identification. BRODERICK, GROUT.

61f. Physical Mineralogy. The form, optical and physical properties of minerals; expansion and conductivity; pyro-electricity; hardness, percussion, and etch figures; cleavage and gliding planes. Broderick.

65f. Crystallography. Projection and geometric relations of crystal planes; crystal nomenclature; the relation of special properties to morphology. A study of crystal models, crystal drawing, identification of minerals from crystal measurements, and mathematical calculation. Broderick.

73f. Economic Geology. Study of non-metallic minerals of economic value, and discussions of geologic guides to prospecting for these deposits. Quirke.

80w. Advanced Historical Geology. The sequence of events in geologic history, of interest to the advanced student in mining. Stauffer.

85su. Field Work. About two weeks in June are spent in geologic mapping of selected areas in the iron district of Minnesota. Involves preparation of geologic maps and written reports. Johnston.

105f. Elements of Rock Study. The occurrence and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. Grout, Broderick.

106w. Petrography. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and metamorphic rocks. The origin and classification of rocks. Grout, Broderick.

111f. Ore Deposits. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. Emmons.

112w. Advanced Economic Geology. First part treats deposits of metals, giving special attention to those outside of the United States. Second half treats the nature, origin, and distribution of petroleum and discusses the various oil fields of the world. Emmons.

113s. Problems in Ore Deposits. Field excursions, map work, lectures on field and laboratory methods. Emmons.

124w, 125s. Structural and Metamorphic Geology. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. Johnston.

131f, 132w, 133s. Advanced Petrology. Advanced optical methods. Criteria for rapid identification of minerals and rocks. The uses of

schedules and tables. Standard rock types. Regional and genetic studies. Petrographic reports. GROUT.

137w. TESTING ECONOMIC MINERALS. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, oil, building stone, and metallic ores. GROUT.

140w, 141s. APPLIED PETROGRAPHY. Determination of ores and gangue minerals. Microscopic studies of paragenesis of ores and other mineral associations. Practical problems in mining and geology settled by microscopic and optical examinations. GROUT.

144w, 145s. CONSTRUCTION AND INTERPRETATION OF GEOLOGIC MAPS. Methods of geologic examination; problems in construction and interpretation of geologic maps and sections. QUIRKE.

150s. FIELD GEOLOGY. Detailed, systematic work conforming with standards of official surveys. Preparation of geological maps, structure sections, reports; paragenesis of ores and their relations to geologic structures. Field for 1920, Black Hills, South Dakota. Reports to be written week before college opens in fall. EMMONS, JOHNSTON.

151f, 152w, 153s. ADVANCED GENERAL GEOLOGY. Geologic processes and their results; development of the North American continent. STAUFFER.

166w, 167s. MINERALOGRAPHY. Methods of studying opaque minerals and the application of the methods to problems in ore genesis and history. BRODERICK.

246. PRE-CAMBRIAN GEOLOGY. The problems of pre-Cambrian correlation and structure; the pre-Cambrian stratigraphy of North America. Given in alternate years. Not offered in 1919-1920. JOHNSTON.

247. GEOLOGY AND EXPLORATION OF LAKE SUPERIOR REGION. The geology of the Lake Superior iron districts. Methods used in the exploration of iron ore; interpretation of drill cores; cartographic expression of drill data; models of drilled areas. Principles of magnetic surveying. JOHNSTON.

GERMAN

Professor CARL SCHLENKER; Assistant Professors OSCAR C. BURKHARD, JAMES DAVIES, ALFRED KOENIG, SAMUEL KROESCH, WALTER R. MYERS.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
1f	Beginning	5	Jr. E.M. (Geol.)	....
2w	Beginning and Intermediate	5	Jr. E.M. (Geol.)	1f
3s	Beginning Advanced	5	Elective	2w
21f	Scientific Intermediate	3	Elective	1f-3s or equiv.
22w	Scientific Intermediate	3	Elective	21f
23s	Scientific Intermediate	3	Elective	22w

1f. Beginning. Double course. Pronunciation, grammar, conversation, and composition; selected readings in easy prose and verse.

2w. Beginning and Intermediate. Double course. Continuation of Course 1f.

3s. Beginning Advanced. Double course. Selected texts in modern narrative and descriptive prose; selected lyrics and ballads; a drama of Lessing, Goethe, or Schiller. Assigned readings of texts outside of class.

21f, 22w, 23s. Scientific Intermediate. This course aims to give students a reading knowledge of German for use in scientific studies.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Associate Professor Samuel L. Hoyt; Instructors Elwyn L. Smith, Ralph L. Dowdell.

COURSES

No.	Title	Lect. hrs.	Lab. hrs.	Required of	Prerequisite courses
1w	Assaying	4	..	All fr.	Chem. 1f, Geol. 23f
2w	Assaying Lab.	..	8	All fr.	Chem. 1f, Geol. 23f
3f	General Metallurgy	3	..	Soph.E.M.&Met.E.	1w, 2w, Chem. 3s
4w	Metallurgy of Pig Iron	3	..	Soph.E.M.&Met.E.	3f
5s	Met. Wrought Iron and Steel	3	..	Soph.E.M.&Met.E.	4w
6f	Ore Testing	2	..	Sr.E.M.&Met.E.	107s
7f	Ore-Testing Lab.	..	8	Sr.E.M.&Met.E.	107s
8w	Spec. Prob. in Ore Test.	..	4	Sr.E.M.&Met.E.	107s
9s	Spec. Prob. in Ore Test.	..	8	Sr.E.M.&Met.E.	107s
10w	Advanced Metallurgy	4	6	Sr.Met.E.	107s
11s	Advanced Metallurgy	4	6	Sr.Met.E.	107s
12f	Ore Dressing	3	..	Jr.E.M.&Met.E.	Phys. 5s, Geol. 25s
13w	Ore Dressing	3	..	Jr.E.M.&Met.E.	Phys. 5s, Geol. 25s
14f	Ore-Dressing Lab.	..	4	Jr.Met.E.	Phys. 5s, Geol. 25s
15w	Ore-Dressing Lab.	..	4	Jr.Met.E.	Phys. 5s, Geol. 25s
16s	Ore-Dressing Lab.	..	6	Jr.Met.E.	Phys. 5s, Geol. 25s
17s	Ore-Dressing Lab.	..	6	Jr.E.M.	Phqs. 5s, Geol. 25s
18f	Thesis in Metallurgy	..	8	Sr.Met.E.	Satisfactory completion of jr. year
19w	Thesis in Metallurgy	..	18	Sr.Met.E.	18f
20s	Thesis & Specifications	..	18	Sr.Met.E.	19w
21s	Field Work in Met.	..	**	Jr.Met.E.	Same as 18f
22w	Mechanical Technology	3	..	Mech. Engineers	.....
105f	Met. of Base Metals	4	..	Jr.E.M.&Met.E.	3f
106w	Met. of Base Metals	4	..	Jr.E.M.&Met.E.	105f
107s	Met. of Precious Metals.	4	..	Jr.E.M.&Met.E.	106w
108f	Electrometallurgy	3	..	Sr.Met.E.	107s
153f	Mphy., Long Course	3	4	Jr.Met.E.	Chem. 20w, Phys. 5s
154w	Mphy., Long Course	3	4	Jr.Met.E.	153f
155s	Mphy., Long Course	3	4	Jr.Met.E.	154w

No.	Title	Lect. hrs.	Lab. hrs.	Required of	Prerequisite courses
156w	Mphy. for Engineers.....	3	4	Elective	Soph. Shop Practice
157s	Adv. Mphy. for Engineers	3	4	Elective	156w
160w	Mphy. for Chemists.....	2	2	Elective	Chem. 20w
161f	Dental Metallography ...	3	..	Elective	.....
163f	Adv. Metallography	To be ar.		Elective	155s
164w	Adv. Metallography	To be ar.		Elective	.....
165s	Adv. Metallography	To be ar.		Elective	.....
201f	Adv. Mphy., Gr. students.	To be ar.		Elective	.....
202w	Adv. Mphy., Gr. students.	To be ar.		Elective	.....
203s	Adv. Mphy., Gr. students.	To be ar.		Elective	.....

** Ten days.

1w. Assaying. The determination of values of ores, metallurgical products by the fire method. Lectures and recitations. Appleby, Christianson.

2w. Assay Laboratory. Practical determination of gold, silver, lead, and tin by the fire method. Christianson, Pease, Smith.

3f. General Metallurgy. Combustion, fuels, refractory materials, furnaces and fluxes. Lectures and recitations. Christianson.

4w. Metallurgy of Pig Iron. General principles of iron blast furnace practice. Construction of furnace, handling of stock, and products, principles of regulation. Lectures and recitations. Christianson.

5s. Metallurgy of Wrought Iron and Steel. General principles involved in the production of wrought iron and steel. Lectures and recitations. Christianson.

6f. Ore Testing. General principles involved in determining the best method of extraction, including amalgamation, concentration, cyanidation, roasting, etc. Lectures and recitations. Christianson.

7f. Ore-Testing Laboratory. Practical determination of extraction and distribution of values in mill and metallurgical products. Methods of calculation. Christianson and Assistants.

8w. Special Problems in Ore Testing. Continuation of Course 7f. Practical determinations for regulating metallurgical operations. Pease.

9s. Special Problems in Ore Testing. Continuation of Course 8w. Pease.

10w. Advanced Metallurgy. Pyrometry, calorimetry, and metallurgical calculations to determine heat balance and heat distribution. Lectures and laboratory work. Christianson.

11s. Advanced Metallurgy. Design of furnaces, conferences and laboratory work. Christianson.

12f. Ore Dressing. Crushing, sizing, classification, and concentration of ores. Lectures and recitations. Smith.

13w. Ore Dressing. Continuation of Course 12f. Smith.

14f. Ore-Dressing Laboratory. Practical examination of ores and the use of ore-dressing machinery. Smith.

15w. Practical Problems in Ore Dressing. Smith.

16s. Ore-Dressing Laboratory. Continuation of Course 15w. Smith.

17s. Ore-Dressing Laboratory. Short course in the laboratory use of ore-dressing machinery. Smith.

18f. Thesis in Metallurgy. Conferences to select suitable problem together with preliminary laboratory work on problem selected. Christianson.

19w. Continuation of Course 18f. Christianson.

20s. Completion of thesis including specifications covering installation of a plant. Christianson.

21s. Field Work in Metallurgy. Study of metallurgical operations at smelters and mills. Detail reports are required covering plants visited. Christianson, Pease.

22w. Mechanical Technology. Lectures on mining, metallurgy, and treatment of metals used in construction. Bains, Christianson, Pease, Hoyt.

105f. Metallurgy of the Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining. Lectures and recitations. Pease.

106w. Metallurgy of Base Metals. Continuation of Course 105f. Pease.

107s. Metallurgy of the Precious Metals. Principles involved and methods used in the extraction of gold, silver, and other precious metals. Lectures and recitations. Pease.

108f. Electrometallurgy. Application of electricity to production of heat for smelting ores and refining metals. Costs of fuel and electricity for heating, relative efficiencies of electric and fuel furnaces. Construction of high temperature furnaces and commercial plants. Christianson.

153f, 154w, 155s. Metallography. (Long course for Metallurgical Engineers.) Theory of metallic alloys. Metallographic technique. Properties of metals and alloys. Metallography of iron and steel and commercial alloys. Technical metallography. Hoyt.

156w. METALLOGRAPHY FOR ENGINEERS. Metallurgy of iron and steel. Microscopic and thermal analysis of steel and cast iron; heat and mechanical treatment. Laboratory work. HOYT.

157s. ADVANCED METALLOGRAPHY FOR ENGINEERS. Continuation of 156w. Metallography applied to engineering practice; commercial heat treatment; uses and properties of alloy steels. Engineering specifications involving the use of metals and alloys. Laboratory work. HOYT.

160w. METALLOGRAPHY FOR CHEMICAL STUDENTS. The preparation of metallic alloys; their microscopical and thermal analysis. Steel and other commercial alloys with particular reference to chemical metallurgy. Corrosion of steel and non-ferrous alloys. Metallography applied to analytical chemistry. HOYT.

161f. DENTAL METALLOGRAPHY. Study of the dental alloys from the standpoint of metallography. HOYT.

163f, 164w, 165s. ADVANCED METALLOGRAPHY. Technical and scientific research. The study of steel rails, automobile and locomotive parts, tool steels, etc. Special problems in metallography with outside reading. Seminar work on the recent advances in metallography. HOYT.

201f, 202w, 203s. ADVANCED METALLOGRAPHY FOR GRADUATE STUDENTS. Repetition and extension of Courses 163f, 164w, and 165s. HOYT.

MINE PLANT AND MECHANICS

Professor ELTING H. COMSTOCK; Assistant Professor ANDERS J. CARLSON; Instructor JAMES C. SANDERSON.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	Algebra and Solid Geometry	6	..	B fr.	..
2f	Algebra	6	..	A fr.	..
3s	Algebra	4	..	B fr.	1f
4w	Trigonometry	6	..	All fr.	..
5s	Analytical Geometry	6	..	All fr.	4w
6f	Calculus	4	..	All soph.	5s
7w	Calculus	3	..	All soph.	6f
8s	Calculus	6	..	All soph.	7w
9f	Mechanics	5	..	Jr.E.M.&Met.E.	8s
10w	Mechanics of Materials	5	..	Jr.E.M.&Met.E.	9f
11s	Mechanics of Materials	5	..	Jr.E.M.&Met.E.	10w
12f	Mine Plant	6	..	Jr.E.M.&Met.E.	8s
13w	Mine Plant	6	..	Jr.E.M.&Met.E.	12f
14s	Mine Plant	6	..	Jr.E.M.&Met.E.	13w
15w	Metallurgical Plant	2	..	Jr.Met.E.	12f
16s	Metallurgical Plant	2	..	Jr.Met.E.	15w
17f	Hydraulics and Water-Power	5	2	Sr.E.M.&Met.E.	9f
18f	Engineering Construction	..	8	Sr.E.M.	11s
19w	Mine Plant Design	..	9	Sr.E.M.	18f
20s	Mine Plant Design	..	12	Sr.E.M.	19w

1f. Algebra and Solid Geometry. Equations, involution and evolution, theory of exponents, surds, quadratic equation, theory of logarithms, determinants. Demonstrations of most important theorems of solid geometry. Volumes, approximate volumes, prismoidal formula, etc. Sanderson.

2f. Algebra. Functions, functional notation, factor and remainder theorems, factors and values of functions, development of functions, progressions, series, theory of equations, permutations and combinations, theory of logarithms, determinants. Comstock, Sanderson.

3s. Algebra, Continuation of 1f. Functions, functional notation, factor and remainder theorems, factors and values of functions, development of functions, progressions, series, theory of equations, permutations and combinations. Sanderson.

4w. Trigonometry. Trigonometric ratios, right triangles, definitions of trigonometric functions, analytic relations, trigonometric equations, etc., solution of spherical triangles. Comstock, Sanderson.

5s. Analytical Geometry. Systems of coördinates, loci, equations, properties of straight line, transformation of coördinates, equations and properties of conics, equations of second degree, higher plane curves, space coördinates, point, plane, quadric surfaces, etc., empirical equations, graphic algebra. Sanderson.

6f, 7w, 8s. Calculus. Differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, indeterminate forms, partial derivatives, change of variable, elementary integration, undetermined coefficients, rationalization, formulas of reduction, some differential equations of mechanics. Sanderson.

9f. Mechanics. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy. Carlson.

10w, 11s. Mechanics of Materials. Mechanical and elastic properties of materials of construction; beams, columns, shafts, hollow cylinders and spheres, rollers, plates; theory of internal stress; reinforced concrete. Carlson.

12f, 13w, 14s. Mine Plant. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, rock drills, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. Comstock.

15w, 16s. Metallurgical Plant. Power, air, and water supply for metallurgical plants. Comstock.

17f. Hydraulics and Water-Power. Laws of the equilibrium, pressure and flow of liquids, estimation of power to be developed at a power site, dams and appendages, theory of water wheels and turbines, speed control, power-house equipment, transmission. Carlson.

18f. Engineering Construction. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures, design of mining structures. Carlson.

19w, 20s. Mine Plant Design. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. Comstock.

MINING

Associate Professor Thomas M. Bains, Jr.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1s	Introductory Mining...	4	..	All soph.	..
2f	Exploration	5	...	All jr.	1s
3w	Tunneling	5	..	All jr.	2f
4s	Mining Methods	5	..	All jr.	3w
5s	Practical Mining	..	2 wks.	All jr.	Satisfactory completion of jr. yr.
6f	First Aid	..	*	All jr.	..
51f	Mine Rescue	..	*	All sr.E.M.&E.M.(Geol.)	..
52f	Mining Reports	5	..	All sr.E.M.&E.M.(Geol.)	4s
53w	Mining Problems	5	..	All sr.E.M.&E.M.(Geol.)	52f
54s	Mining Law	5	..	All sr.E.M.&E.M.(Geol.)	53w
55f	Thesis	..	2	All sr.E.M.	4s
56w	Thesis	..	12	All sr.E.M.	55f
57s	Thesis	..	12	All sr.E.M.	56w

* 15 hours (1 week).

1s. Introductory Mining. Introductory mining course, preparatory to sophomore field trip. Bains.

2f. Exploration. Occurrence of ore-bodies, prospecting, exploration, boring and surface excavation. Bains.

3w. Tunneling. Explosives, drilling, tunneling, drifting, shaft sinking and raising. Bains.

4s. Mining Methods. Underground mining methods and support of underground excavations. Bains.

5s. Practical Mining. Study of mining operations. Mine plant and mining work in one or more mining camps. Comstock, Bains.

6f. First Aid. Course in first aid to the injured, given by the staff of the U. S. Bureau of Mines car.

51f. MINE RESCUE. Course in mine rescue, given by the staff of the U. S. Bureau of Mines car.

52f. MINING REPORTS. Preparation of one or more mining reports, from data supplied by the Mining Department; open-pit work, quarrying, placer mining, hydraulic mining and dredging. BAINS.

53w. MINING PROBLEMS. Coal mining methods, mine drainage, mine ventilation, mine transportation, mine sanitation, mine hygiene, cost accounting, and mine examination. BAINS.

54s. MINING LAW. Course in mining law, mine management and economics of mining. BAINS.

55f. THESIS. Preparatory work on the mining thesis. BAINS.

56w. THESIS. Preparation of an original thesis on some mining project, covering the exploration and development of a mining property. BAINS.

57s. THESIS. Completion of thesis project. BAINS.

MINING ENGINEERING

Associate Professor EDWIN M. LAMBERT.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	Mine Surveying	3	..	All soph.	Math. 4w
2w	Mine Surveying	3	..	All soph.	1f
3s	Mine Surveying	3	4	All soph.	2w
4s	Field Work	..	7 wks.	All soph.	3s
5w	Mine Mapping	..	6	All jr.	4s
6s	Mine Mapping	..	6	All jr.	5w

1f-2w-3s. MINE SURVEYING. Theory and problems in mine surveying including land subdivision, stadia measurements, triangulation, railroad curves and cross sections, computation of areas by coördinates; differential leveling, topographic map reading, solar observations, shaft plumbing, underground traversing and leveling. LAMBERT.

4s. FIELD WORK. Practice in general plane surveying during the month of May. Practice in underground surveying during the first three weeks of June. This work is given on the iron ranges of Minnesota. LAMBERT, CARLSON.

5w-6s. MINE MAPPING. Mine mapping in accordance with prevalent practice in western mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. CARLSON.

PHYSICS

Professors Henry A. Erikson, Anthony Zeleny; Professorial Lecturer Louallen F. Miller.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	General Physics	3	..	All soph.	Math. 5s
3w	General Physics	3	..	All soph.	1f
5s	General Physics	3	..	All soph.	3w
2f	General Lab. Practice	..	2	All soph.	With 1f
4w	General Lab. Practice	..	2	All soph.	With 3w
6s	General Lab. Practice	..	2	All soph.	With 5s

1f. General Physics. Mechanics, heat, and sound. Treatment of such fundamental principles and problems as will best serve mining or metallurgical engineers in practical work, and develop investigative insight necessary for the solution of mining and metallurgical problems. Miller.

3w, 5s. General Physics. Electricity, magnetism, and light, as stated under Course 1f. Theory illustrated by practical applications. Enough of light given to understand optical instruments of mining and metallurgy, and comprehend optical principles of crystal structure in crystallography. Miller.

2f. General Laboratory Practice. Measurements in mechanics and heat. Intended to develop accuracy, method, system, and experimental control. Miller.

4w, 6s. General Laboratory Practice. Measurements in electricity, magnetism, and light. The experiments in light being largely supplementary to the purposes stated in Courses 3w and 5s. Miller.

ROMANCE LANGUAGES

Professors Everett Ward Olmsted, Irville C. Le Compte, Colbert Searles; Assistant Professors Francis B. Barton, Jules T. Frelin, Ruth S. Phelps.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
4f	Beginning French	5	Jr. E.M. (Geol.)	....
5w	Beginning French	5	Jr. E.M. (Geol.)	4f
6s	Intermediate French	5	Elective	5w
10f	Survey French Lit.	3	Elective	6s
11w	Survey French Lit.	3	Elective	10f
12s	Survey French Lit.	3	Elective	11w
34f	Beginning Spanish	5	Jr. E.M. (Geol.)	....
35w	Beginning Spanish	5	Jr. E.M. (Geol.)	34f
36s	Intermediate Spanish	5	Elective	35w
40f	Spanish Literature	3	Elective	36s
41w	Spanish Literature	3	Elective	40f
42s	Spanish Literature	3	Elective	41w

4f, 5w. Beginning French. Stress on accurate pronunciation, reading, reading vocabulary, and the essentials of grammar. Daily oral and written exercises (dictation and reproduction in French).

6s. Intermediate French. French grammar, composition, and reading; increased use of French in the classroom. Selections from modern prose and poetry.

10f, 11w, 12s. General Survey of French Literature. Lectures, recitations, and assigned readings. Designed to cover the whole period in historical outline. Selections from representative authors.

34f, 35w. Beginning Spanish. Pronunciation, grammar, oral exercises and translation.

36s. Intermediate Spanish. Review of grammar, composition, conversation and reading.

40f, 41w, 42s. Spanish Literature. Discussions based upon texts and collateral reading.

STUDENTS

GRADUATE SPECIAL—1

Ingersoll, Guy E., Hibbing

SENIORS—8

Barr, J. Carroll, Jr., Pittsburgh, Pa.
Berg, Locksley D., Minneapolis
Frellsen, Sidney A., Minneapolis
Goldberg, Bert, St. Paul
Goldberg, Samuel B., St. Paul
Hosted, Joseph O., Duluth
Mellem, Walter R., St. Paul
Pan, Wen Ping, Shanghai, China

JUNIORS—12

Arnold, Lewis E., Minneapolis
Davies, Herman F., Minneapolis
Donaghue, Abner J., Minneapolis
Johnson, Axel L., Benson
Kersten, Erwin H. W., Minneapolis
Mark, Israel C., Minneapolis
Munson, Arthur M., St. Paul
Olson, Paul W., Warren
Peterson, Clarence D., Minneapolis
Powers, Sheldon M., Minneapolis
Raiter, Clifford R., Minneapolis
Wheeler, James D., Minneapolis

SOPHOMORES—17

Butler, Roy G., St. Paul
Carlson, Edwin N., Brainerd
Chadbourn, Charles H., Minneapolis
Dawson, Loren W., Minneapolis
Hamernik, Frank J., Menominee, Mich.
Hope, Lawrence I., Minneapolis
Johnsen, Trygve, St. Paul
Johnston, Kenneth A., St. Paul
Nicholls, William J., Jr., Ely
Patten, Richard C., Minneapolis
Rydlun, Edwyn G., Minneapolis
Sebenius, Carl H., Duluth
Strange, Howard E., Duluth
Walz, Clarence M., Gladstone, Mich.
West, Herbert S., Minneapolis
Yaeger, William H., Valley City, N. D.
Zanger, Eugene, Minneapolis

FRESHMEN—43

Adams, E. Maurice, Moorhead
Alger, Leon J., Staples
Anderson, Oscar B., Crosby
Apuli, Waino E., Mountain Iron
Barker, Clifton T., Excelsior
Borgeson, Milton B., Hibbing
Branley, Bernard L., Melrose
Butler, Robert, St. Paul
Casson, Robert D., Duluth
DeVaney, Fred D., Minneapolis
Echebarria, Luis de Uribe, Bilbao, Spain
Friedl, Arthur J., St. Paul
Goldman, Theodore I., Minneapolis
Gross, Forrest C., Duluth
Gustafson, Arnold A., Duluth
Hansen, Mayer G., Minneapolis
Heathcote, William, Duluth
Henkel, Howard L., Minneapolis
Hoffman, Louis, Minneapolis
Kilp, Raymond G., Minneapolis
Knowlton, Ralph S., Duluth
Le Roy, James K., Minneapolis
Lin, Sze Chen, Peking, China
Loulan, William F., Kinney
Lovering, Thomas S., St. Paul
McKenzie, Frederick R., Adrian
Mannerberg, Walter F., Minneapolis
Merrill, John W., St. Paul
Moga, Gregory, St. Paul
Olson, Arthur W., Minneapolis
Plut, Frank J., Crosby
Ridgway, Robert H., Mandan, N. D.
Scheid, Adolph J., Jr., Milwaukee, Wis.
Sebenius, William H. M., Duluth
Siverling, Milo T., Albert Lea
Siverson, Garfield C., Minneapolis
Smith, Lyle W., Minneapolis
Swart, John A., Duluth
Tappen, William H., Hibbing
Thellin, Herbert E., Crosby
Webster, W. H., Minneapolis
Williams, Barton, Olean, N. Y.
Wilson, J. Byron, Minneapolis

FIRST YEAR—23

Allen, Arthur W., Minneapolis
Allen, Lauren L., Minneapolis
Blair, John V., Winona
Edwards, Roger D., Albert Lea
Fay, Charles M., Duluth
Finch, Frank C., Lemmon, S. D.
Grover, Willard A., Winona
Gudmundson, Staney L., Minneota
Hall, Howard C., Minneapolis
Liddicoat, Roy H., Biwabik
Middleton, John L., Marshall
Norin, Adolph L., Minneapolis
Rea, Vernon A., Oshkosh, Wis.
Schroeder, William A., St. Paul
Schultz, Dewey, Kinney
Searles, John N., Mazeppa
Thompson, Harry S., St. Paul
Watts, Clement J., Crosby
Welu, Barney J., Milroy
Wilcox, Fred H., Minneapolis
Wilson, Lawrence A., Minneapolis
Wolfe, Maurice, Hibbing
Wright, Donald R., Luverne

The Bulletin of the University of Minnesota

The School of Mines Announcement for the Year 1920-1921

Vol. XXIII No. 14 May 8 1920

Entered at the post-office in Minneapolis as second-class matter Minneapolis, Minnesota

Accepted for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized July 12, 1918

1920

JULY

Su	Mo	Tu	W	Th	Fr	Sa
..	..	..	..	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
..	..	..	..	..	..	..

AUGUST

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	..	..	..	..
..	..	..	..	..	..	..

SEPTEMBER

..	..	..	1	2	3	4
5	6	**7**	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	**29**	30	..	..
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OCTOBER

..	..	..	..	..	1	2
3	4	5	6	7	8	9
10	**11**	**12**	**13**	**14**	**15**	**16**
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	..	..	..	..	..	..

NOVEMBER

..	1	**2**	3	4	5	6
7	8	9	**10**	**11**	**12**	**13**
14	15	16	17	18	19	20
21	22	23	24	**25**	26	27
28	29	30	..	..	..	..
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DECEMBER

..	..	..	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	**23**	**24**	**25**
26	**27**	**28**	**29**	**30**	**31**	..
..	..	..	..	..	..	..

1921

JANUARY

Su	Mo	Tu	W	Th	Fr	Sa
..	..	..	..	..	..	**1**
2	**3**	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	..	..	..	..	..

FEBRUARY

..	..	1	2	3	4	5
6	7	8	9	10	11	**12**
13	14	15	16	17	18	19
20	21	**22**	23	24	25	26
27	28	..	..	..	..	..
..	..	..	..	..	..	..

MARCH

..	..	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	**25**	**26**
27	**28**	**29**	30	31	..	..
..	..	..	..	..	..	..

APRIL

..	..	..	..	..	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
..	..	..	..	..	..	..

MAY

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	**30**	31	..	..	..	..
..	..	..	..	..	..	..

JUNE

..	..	..	1	2	3	4
5	6	7	8	9	10	11
12	13	14	**15**	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	..	..
..	..	..	..	..	..	..

JULY

Su	Mo	Tu	W	Th	Fr	Sa
..	..	..	..	..	1	2
3	**4**	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	..	..	..	..	..	..

AUGUST

..	1	2	3	4	5	6
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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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CALENDAR

1920-1921

1920

September	17	Friday	Sophomores, School of Mines, report for military drill 8:30 a.m.
September	18	Saturday	Payment of fees closes, except for new students
September	21	Tuesday	Juniors and seniors, School of Mines, report for completion of field work
September	24-28	Week	Examinations for removal of conditions and entrance examinations; see below
September	27-28		Registration days
September	29	Wednesday	Fall quarter begins
October	21	Thursday	Senate meeting, 4:00 p.m.
November	2	Tuesday	Election Day; a holiday
November	25	Thursday	Thanksgiving Day; a holiday
December	16	Thursday	Senate meeting, 4:00 p.m.
December	22	Wednesday	Christmas vacation begins 5:20 p.m.

1921

January	4	Tuesday	Christmas vacation ends 8:30 a.m.
January	4	Tuesday	Winter quarter begins 8:30 a.m.
February	12	Saturday	Lincoln's Birthday; a holiday
February	17	Thursday	Senate meeting, 4:00 p.m.
February	22	Tuesday	Washington's Birthday; a holiday
March	24	Thursday	Winter quarter ends 5:20 p.m.
March	30	Wednesday	Spring quarter begins 8:30 a.m.
May	2	Monday	Field work for sophomores and juniors in School of Mines begins
May	19	Thursday	Senate meeting, 4:00 p.m.
May	30	Monday	Memorial Day; a holiday
June	12	Sunday	Baccalaureate service
June	14	Tuesday	Spring quarter closes 5:20 p.m.
June	15	Wednesday	Forty-ninth annual commencement
June	20	Monday	Summer session begins
July	30	Friday	Summer session closes

Program of Supplementary Examinations

Friday,	Sept. 24	9-12 a.m.	Physics
		2-5 p.m.	Chemistry, experimental engineering
Saturday,	Sept. 25	9-12 a.m.	Mathematics and mechanics
		2-5 p.m.	Drawing and descriptive geometry
Monday,	Sept. 27	9-12 a.m.	Metallurgical subjects
		2-5 p.m.	Electrical and mechanical engineering subjects, mine plant and surveying
Tuesday,	Sept. 28	9-12 a.m.	Geology and mineralogy
		2-5 p.m.	Mining subjects

THE SCHOOL OF MINES

FACULTY

MARION LEROY BURTON, Ph.D., D.D., LL.D., President[1]
LOTUS DELTA COFFMAN, Ph.D., President-elect
WILLIAM WATTS FOLWELL, LL.D., President Emeritus
CYRUS NORTHROP, LL.D., President Emeritus
WILLIAM R. APPLEBY, M.A., Dean, and Professor of Metallurgy
FRANCIS B. BARTON, Docteur de l'Université de Paris, Assistant Professor of Romance Languages
THOMAS M. BRODERICK, Ph.D., Assistant Professor of Geology
WILLIAM E. BROOKE, B.C.E., M.A., Professor of Mathematics and Mechanics
ANDERS J. CARLSON, C.E., Assistant Professor of Mine Plant and Mechanics
PETER CHRISTIANSON, B.S., E.M., Professor of Metallurgy
ELTING H. COMSTOCK, M.S., Professor of Mine Plant and Mechanics
JAMES DAVIES, Ph.D., Assistant Professor of German
WILLIAM H. EMMONS, Ph.D., Professor of Geology and Mineralogy
HENRY A. ERIKSON, B.E.E., Ph.D., Professor of Physics
JULES T. FRELIN, B.A., Assistant Professor of Romance Languages
ROBERT W. FRENCH, B.S. in C.E., Assistant Professor of Drawing and Descriptive Geometry
ISAAC W. GEIGER, Ph.D., Assistant Professor of Chemistry
ALBERT G. GOODWYN, Captain, Infantry, U.S.A., Professor of Military Science and Tactics
FRANK F. GROUT, M.S., Ph.D., Professor of Geology and Mineralogy
OSCAR E. HARDER, Ph.D., Associate Professor of Metallography
WILLIAM F. HOLMAN, Ph.D., Associate Professor of Mathematics and Mechanics
A. WALFRED JOHNSTON, M.A., Assistant Professor of Geology
LAUDER W. JONES, Ph.D., Professor of Chemistry
WILLIAM H. KIRCHNER, B.S., Professor of Drawing and Descriptive Geometry
SAMUEL KROESCH, Ph.D., Assistant Professor of German
EDWIN M. LAMBERT, M.E., Associate Professor of Mining Engineering
IRVILLE C. LECOMPTE, Ph.D., Professor of Romance Languages
LOUALLEN F. MILLER, B.S., M.A., Professorial Lecturer in Physics
WALTER R. MYERS, Ph.D., Assistant Professor of German
EVERETT W. OLMSTED, Ph.D., Professor of Romance Languages
WALTER H. PARKER, E.M., Associate Professor of Mining
LEVI B. PEASE, M.S., Professor of Metallurgy
RUTH S. PHELPS, M.A., Associate Professor of Romance Languages
FRANK B. ROWLEY, M.E., Associate Professor of Mechanical Engineering

[1] Resigned July 1, 1920.

William T. Ryan, E.E., Associate Professor of Electrical Engineering
Carl Schlenker, B.A., Professor of German
Colbert Searles, Ph.D., Professor of Romance Languages
George D. Shepardson, M.A., M.E., D.Sc., Professor of Electrical Engineering
Charles F. Shoop, B.S., Associate Professor of Experimental Engineering
Charles F. Sidener, B.S., Professor of Chemistry
Edward H. Sirich, Ph.D., Associate Professor of Romance Languages
M. Cannon Sneed, Ph.D., Associate Professor of Chemistry
Clinton R. Stauffer, B.S., Ph.D., Professor of Geology
Anthony Zeleny, M.S., Ph.D., Professor of Physics
Leon Archibald, B.S., Instructor in Drawing and Descriptive Geometry
Ralph L. Dowdell, Met.E., Instructor in Metallography
Lynwood Downs, M.A., Instructor in German
Carl O. Dunbar, Ph.D., Instructor in Geology
Howard D. Myers, B.S. in C.E., Instructor in Dra ing and Descriptive Geometry
Orrin W. Potter, E.M., Instructor in Drawing and escriptive Geometry
Burton J. Robertson, E.E., Instructor in Experimental Engineering
James C. Sanderson, Ph.D., Instructor in Mine Plant and Mechanics
Elwyn L. Smith, B.S., Instructor in Metallurgy
Arthur J. Tieje, Ph.D., Instructor in Geology
Elizabeth B. Henderson, Librarian

GENERAL INFORMATION

The School of Mines was established by the Board of Regents in 1888, upon recommendation of the general faculty of the University. The buildings and laboratories of the school are located on the main campus of the University. The mining districts of Minnesota are within a few hours, by rail, from Minneapolis. The heartiest coöperation exists between the various mine managements and the school, so that the mining properties are at all times open to parties from the school for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts. Students in the School of Mines have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

The School of Mines occupies the new building provided by the Legislature of 1913. In the basement are the assay and electro-metallurgical laboratories, together with machinery room, instrument room, balance-room, furnace-rooms, and necessary storerooms. On the first floor are the administrative offices, and offices and lecture-rooms of the departments of Metallurgy and Mine Plant and Mechanics. On the second floor are the offices, lecture-rooms, and drafting-rooms of the Department of Mining, the ore-dressing laboratory, and the library of the school. On the third floor are the offices, laboratories, and lecture-rooms of the Department of Metallography, the Department of Mining Engineering, junior drafting-room, photographic darkrooms, blue-printing room, and offices and computing rooms for the branch of the experiment station serving the tax commission.

DEGREES

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degrees of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M.(Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four years, and vice versa, provided such candidate completes an additional year's work at the school and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and Architecture, and in the School of Chemistry, who contemplate taking a degree in this school after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thoro courses in mechanics, mathematics, surveying, physics, chemistry,

and the necessary theory and practice of structural, mechanical, and electrical engineering.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine if it has value for treatment. (d) *Mining engineering*—to furnish material for treatment. (e) *Ore-testing*—to determine best methods of treatment. (f) *Ore-dressing*—to furnish products for metallurgical treatment. (g) *Metallurgy*—to smelt and refine ores and ore-dressing products; reduction to metals. (h) *Metallography*—to study metals and their alloys.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the state; to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the tax commission, and to do such other work along the lines above outlined as may be requested by other state departments. Coöperation has been effected with the United States Bureau of Mines, the United States Geological Survey, the Minnesota Geological Survey, and the School of Chemistry.

The experiment station is prepared to assist citizens interested in these lines of work, and to assay specimens of ore, rocks, clays, and minerals found within the state, free of charge.

In submitting samples the sender must state the exact location where each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the office of the station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, the University of Minnesota, Minneapolis, Minnesota.

ADMISSION

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology), and Metallurgical Engineer may be completed in four years.

Freshmen will be divided into two sections as follows:

a. Those entering with credits in higher algebra and solid geometry.

b. Those entering without credits in higher algebra and solid geometry. Students in section b will carry a special course in mathematics during their freshman year.

Details as to admission and entrance requirements, description of subjects accepted for admission, and list of fees and expenses will be found in the bulletin of general information, which will be sent to any address upon application to the registrar, the University of Minnesota, Minneapolis.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

ADMISSION TO ADVANCED STANDING

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrollment Committee of the School of Mines.

GRADUATION

Students completing courses of study to the satisfaction of the faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examination in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least the full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examination for the third quarter. Irregular attendance will debar a student from entering all final examinations.

THESIS

The thesis work is intended to bring in review and connect the work in mining and metallurgy, geology and mineralogy, mechanical and electrical engineering, mathematics and mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of field work at the School of Mines, Tuesday, September 21, 1920, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the school.

SPECIAL NOTES

Students failing to receive a quarter mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the registrar his average in all subjects and present himself for supplementary examinations, according to the program on page 3.

Failure of the registrar to notify a student of deficiencies will not be accepted as a reason for neglecting to report for necessary supplementary examinations. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

Students failing to receive a quarter mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination for any quarter will be given zero on the examinations.

Students whose absences in any quarter exceed 20 per cent of the scheduled class hours will not be permitted to take examinations without special permission of the faculty.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

During the academic year students will be held responsible for the receipt of official communications sent to them through the University post-office. During the summer vacation they will be held responsible for the receipt of such communications sent to the home address given on registration blank for the preceding academic year, unless formal notification of their correct address is filed with the registrar and the dean.

COURSES OF STUDY

UNIFORM CURRICULUM TO END OF SOPHOMORE YEAR

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology), and Metallurgical Engineer are uniform for the first two years.

Freshmen will be divided into two sections as follows:

a. Those entering with credits in advanced algebra and solid geometry.

b. Those entering without credits in advanced algebra and solid geometry.

Subjects with the prefix a are to be taken by freshmen in section a; those with the prefix b are to be taken by freshmen in section b; and those without prefix are to be taken by students of both sections.

FRESHMAN YEAR

First Quarter

Chemistry 1f,* General Inorganic, 7†
Drawing 11f, Engineering Drawing, 10
a. Mathematics 2f, Algebra, 6
b. Mathematics 1f, Algebra and Solid Geometry, 6
Mineralogy 23f, Elements of Mineralogy, 8
Military Drill

Second Quarter

Chemistry 2w, General Inorganic, 7, Chem. 1f
Drawing 12w, Engineering Drawing, 8, Draw. 11f
Mathematics 4w, Trigonometry, 6
Metallurgy 1w, Assaying, 4, Chem. 1f, Mineral. 23f
Metallurgy 2w, Assaying Laboratory, 8, Chem. 1f, Mineral. 23f
Mineralogy 24w, Elements of Mineralogy, 4
Military Drill

Third Quarter

Chemistry 3s, General Inorganic, 7, Chem. 2w
Drawing 13s, Engineering Drawing, 8, Draw. 12w
Mathematics 5s, Analytical Geometry, 6, Math. 4w
b. Mathematics 3s, Algebra, 4, Math. 1f
Mineralogy 25s, Elements of Mineralogy, 8
Military Drill

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* The suffixes f,w, or s, after the course number indicate the quarter in which a course is offered—fall, winter, or spring quarter respectively. Two or three suffixes indicate that a course is offered in each of the corresponding quarters.

† Figure following the descriptive name of a course indicates number of hours per week. Course names following indicate prerequisite courses.

SOPHOMORE YEAR

First Quarter

Chemistry 11f, Qualitative Analysis, 7, Chem. 3s
Drawing 14f, Descriptive Geometry, 3, Draw. 13s, Math. 5s
Geology 105f, Rock Study, 4, Geol. 25s
Mathematics 6f, Calculus, 4, Math. 5s
Metallurgy 3f, General, 3, Met. 1w, 2w, Chem. 3s
Mining Engineering 1f, Mine-Surveying, 3, Math. 4w
Physics 23f, Elements of Mechanics, 3, Math. 5s
Physics 24f, Mechanics Laboratory, 2, Math. 5s
Military Science and Tactics, 2a, 2b, or 2c.

Work in military science and tactics for sophomores will open on Friday, Sept. 17, at 8:30 a.m., and continue for ten days. Satisfactory completion of Course 2a, 2b, or 2c, at that time is required of all sophomores. This course applies only to sophomores who are required to leave the following May 1 for field work.

Second Quarter

Chemistry 20w, Quantitative Analysis, 8, Chem. 11f
Drawing 15w, Drafting, 4, Draw. 14f
Geology 1w, General, 3, Geol. 125f
Geology 106w, Petrography, 4, Geol. 105f
Mathematics 7w, Calculus, 3, Math. 6f
Metallurgy 4w, Met. of Pig Iron, 3, Met. 3f
Mining Engineering 2w, Mine-Surveying, 3, Min. Eng. 1f
Physics 43w, Heat, 3, Phys. 23f
Physics 44w, Heat Laboratory, 2, Phys. 23f

Third Quarter

Geology 2s, General, 7, Geol. 105f
Mathematics 8s, Calculus, 6, Math. 7w
Metallurgy 5s, Wrought Iron and Steel, 3, Met. 4w
Mining 1s, Introductory Mining, 4
Mining Engineering 3s, Mine-Surveying, 7, Min. Eng. 2w
Physics 63s, Magnetism and Electricity, 3, Phys. 43w
Physics 64s, Magnetism and Elec. Lab., 2, Phys. 43w

Mining Engineering 4s, Field Work beginning about May 1, 7 weeks, Min. Eng. 3s
Geology 85, Field Work beginning about June 20, 2 weeks, Geol. 2s
Underground Mining Work beginning about July 5

JUNIOR AND SENIOR YEARS

COURSES LEADING TO THE DEGREE OF ENGINEER OF MINES

JUNIOR YEAR

First Quarter

Experimental Engineering, M.E. 83.4f, Elementary Lab. 4, with Mech. 12f
Geology 73f, Economic, 3, Geol. 2s, 105f
Mechanics 9f, Mechanics, 5, Math. 8s

Mechanics 12f, Mine Plant, 6, Math. 8s
Metallurgy 105f, Base Metals, 4, Met. 3f
Metallurgy 12f, Ore-Dressing, 3, Phys. 5s, Geol. 25s
Mining 2f, Exploration, 5, Mining 1s
Mining 6f, First Aid, 1 week

Second Quarter

Experimental Engineering, M. & M. 43.2w, Materials-Testing Lab., 4, with Mech. 10w
Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mechanics 13w, Mine Plant, 6, Mech. 12f
Metallurgy 106w, Base Metals, 4, Met. 105f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f
Mining 3w, Tunneling, 5, Mining 2f
Mining Engineering 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Mechanics 11s, Mechanics of Materials, 5, Mech. 10w
Mechanics 14s, Mine Plant, 6, Mech. 13w
Metallurgy 107s, Precious Metals, 4, Met. 106w
Metallurgy 17s, Ore-Dressing Lab., 6, Met. 13w
Mining 4s, Mining Methods, 5, Mining, 3w
Mining Engineering 6s, Mine-Mapping, 6, Min. Eng. 5w
Metallurgy 21s, Field Work in Metallurgy beginning about May 1, 10 days, satisfactory completion of junior year
Mining 5s, Field Work in Mine Plant and Mining beginning about May 10, 2 weeks, satisfactory completion of junior year

SENIOR YEAR

First Quarter

Electrical Engineering 41f, Electric Power, 5, Phys. 5s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Mechanics 17f, Water Power, 7, Mech. 9f
Mechanics 18f, Engineering Construction, 8, Mech. 11s
Metallurgy 6f, Ore-Testing, 2, Met. 107s
Metallurgy 7f, Ore-Testing Lab., 8, Met. 107s
Mining 52f, Mining Reports, 5, Mining 4s
Mining 51f, Mine Rescue, 1 week
Mining 55f, Thesis, 2, Mining 4s

Second Quarter

Experimental Engineering, M.E. 184.1w, Experimental Lab. 4, Exp. Eng. M.E. 83.4f
Geology 112w, Petroleum, 3, Geol. 111f
Geology 80w, Advanced Historical, 3, Geol. 73f
Mechanics 19w, Mine Plant Design, 9, Mech. 18f
Metallurgy 8w, Special Problems, 4, Met. 107s

Mining 53w, Mining Problems, 5, Mining 52f
Mining 56w, Thesis, 12, Mining 55f

Third Quarter

Geology 113s, Problems in Ore Deposits, 4, Geol. 112w
Mechanics 20s, Mine Plant Design, 12, Mech. 19w
Metallurgy 9s, Special Problems, 8, Met. 107s
Mining 54s, Mining Law, 5, Mining 53w
Mining 57s, Thesis, 12, Mining 56w

DEPARTMENT OF MINING

The department is well supplied with samples of the smaller mine equipment, models, drawings, photographs, lantern slides, and mine maps. The lectures treat of prospecting, development, support of excavations, mining methods, mine administration, mining law, and the necessary allied subjects. The courses in mining extend through the sophomore, junior, and senior years.

FIELD WORK IN MINING

JUNIOR YEAR

At the end of the junior year students are required to study mine plant and mining methods in one or more mining districts under the direction of members of the faculty. This work begins about May 1, and not over three weeks will be devoted to it. The work is carried on in the leading western metal mining districts, the exact location to be announced in April of each year. The expenses for the trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover board and lodging and necessary side trips. Any balance will be returned at the close of the work in the field.

All notes, data, and sketches, necessary for a complete report on the field work, must be fully and neatly recorded in notebooks. These notebooks will be collected at the close of the trip and returned to the student at the reopening of field work at the school. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below the standard that should be demanded of candidates for senior work. During the months of June, July, and August, the student is urged to spend at least six weeks in actual underground mining work in the West, for which he may receive wages. The department will render all possible assistance in locating students in districts of their choice.

Field work will reopen at the School of Mines, Tuesday, September 21, 1920. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in Mining and Metallurgy must be prepared at the School of Mines under the direct supervision of the

departments concerned: Metallurgy, September 21 to 28, inclusive; Mining and Mine Plant, September 29 to October 12, inclusive.

On October 12 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 12. These reports shall become the property of the school.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reason, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

DEPARTMENT OF MINING ENGINEERING

MINE-SURVEYING

The work in surveying is given in the sophomore year and is designed primarily for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi, Cuyuna, or Vermilion Range. The exact location will be announced in March of each year. The expenses for this trip are estimated at $150.

The students will be divided into squads of two to four. Each student will be required to complete satisfactorily a practical course in plane and underground surveying including exercises in chaining and taping; adjustment and use of surveying instruments; solar and stellar observations; laying out railroad tangents and curves; making earthwork estimates; and other problems. In addition each squad will be required to make a yardage estimate of the stripping of an open-pit mine; to transfer a meridian, from the surface, underground and make a complete survey of an underground mine.

The data obtained will be used in the course in mine-mapping during the winter quarter of the junior year.

A full equipment of surveying instruments of the latest and best types is furnished each squad for this work.

Courses Leading to the Degree of Engineer of Mines (in Geology)

JUNIOR YEAR

First Quarter

Chemistry 123f, Iron and Steel Analysis, 7, Chem. 20w
Geology 61f or 65f, Physical Mineralogy or Crystallography, 6, Mineralogy 25s
Geology 73f, Economic, 3, Geol. 2s, 105f
Geology 131f, Advanced Petrology, 6, Geol. 2s, 106w
Geology 151f, Advanced General, 3, Geol. 73f
German 4f or 7f, or French 4f or 30f, or Spanish 204f or 230f, 5 or 3
Mining 2f, Exploration, 5, Min. 1s
Mining 6f, First Aid, 1 week
Electives, 6

Second Quarter

Chemistry 124w, Mineral and Ore Analysis, 7, Chem. 20w
Geology 124w, Struct. and Metamorphic, 3, Geol. 73f, 105f
Geology 132w, Advanced Petrology, 6, Geol. 2s, 106w
Geology 144w, Geologic Maps, 6, Geol. 73f
Geology 152w, Advanced General, 3, Geol. 73f
German 5w or 25w, or French 5w or 31w, or Spanish 205w or 231w, 5 or 3
Mining 3w, Tunneling, 5, Min. 2f
Mining Engineering 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Geology 125s, Struct. and Metamorphic, 6, Geol. 73f, 105f
Geology 133s, Advanced Petrology, 6, Geol. 2s, 106w
Geology 145s, Geologic Maps, 12, Geol. 73f
Geology 153s, Advanced General, 3, Geol. 73f
Mining 4s, Mining Methods, 5, Min. 3w
Electives, 3
Geology 150s, Field Work in Geology beginning about May 1, six weeks, Geol. 125s
Geologic Field Work beginning about June 15 with geological surveys or private companies

SENIOR YEAR

First Quarter

Geology 41f, Paleontology, 3, Geol. 2s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Metallurgy, 12f, Ore-Dressing, 3, Phys, 5s, Geol. 25s
Mining 52f, Mining Reports, 5, Min. 4s
Mining 51f, Mine Rescue, 1 week
Thesis, 8
Electives, 9

Second Quarter

Geology 42w, Paleontology, 3, Geol. 2s
Geology 112w, Petroleum, 3, Geol. 111f
Geology 137w, Testing Economic Materials, 5, Geol. 73f
Geology 140w, Applied Petrography, 5, Geol. 111f, 13s
Geology 166w, Mineralography, 6, Geol. 111f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f
Mining 53w, Mining Problems, 5, Min. 52f
Thesis, 3
Electives, 3

Third Quarter

Geology 43s, Paleontology, 3, Geol. 2s
Geology 113s, Problems in Ore Deposits, 4, Geol. 112w
Geology 141s, Applied Petrography, 5, Geol. 111f, 13s
Geology 167s, Mineralography, 6, Geol. 111f
Metallurgy 17s, Ore-Dressing Lab., 6, Met. 13w
Mining 54s, Mining Law, 5, Min. 53w
Thesis, 10

FIELD WORK IN GEOLOGY

At the end of the sophomore year mining students are required to devote about three weeks to geologic mapping. This course usually comes after a seven weeks' course in surveying and the fields chosen are the Vermilion and Mesabi iron ranges of Minnesota. This work is intended to train the students in the interpretation of field relations and the preparation of geologic maps and cross-sections.

The second field course in geology is required only of those students who are candidates for the Engineer of Mines in Geology degree. The course begins early in May and is completed in June. The course requires altogether about six weeks' work, and the field chosen is the Black Hills region of South Dakota or some other western region. The student is trained in the interpretation of field data; in detailed mapping, underground and on the surface; in the preparation of geologic cross-sections through mines; and he may gather material which will serve as a basis for future study in advanced courses the following year. The work conforms to the standards of official surveys as nearly as practicable. At the close of the field season the students are expected to obtain positions with mining companies either as miners or as engineers, or if openings are available, they may enter geological surveys for the season's work.

Field work in geology for students having taken either of the above trips will reopen at the School of Mines, Tuesday, September 21, 1920. The final reports covering the field work must be prepared at the School of Mines under the direct supervision of the Department of Geology. These reports are to be turned in to the department on September 28.

Courses Leading to the Degree of Metallurgical Engineer

JUNIOR YEAR

First Quarter

Geology 73f, Economic, 3, Geol. 2s, 105f
Mechanics 9f, Mechanics, 5, Math. 8s.
Mechanics 12f, Mine Plant, 6, Math. 8s
Metallurgy 12f, Ore-Dressing, 3, Phys. 5s, Geol. 25s
Metallurgy 14f, Ore-Dressing Lab., 4, Phys. 5s, Geol. 25s
Metallurgy 105f, Base Metals, 4, Met. 3f
Metallurgy 153f, Metallography, 7, Chem. 20w, Phys. 5s
Mining 6f, First Aid, 1 week

Second Quarter

Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mechanics 15w, Metallurgical Plant, 3, Mech. 12f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f, 14f
Metallurgy 15w, Ore-Dressing Lab., 4, Met. 12f, 14f
Metallurgy 106w, Base Metals, 4, Met. 105f
Metallurgy 154w, Metallography, 7, Met. 153f
Mining Engineering, 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Mechanics 11s, Mechanics of Materials, 5, Mech. 10w
Mechanics 16s, Metallurgical Plant, 3, Mech. 13w
Metallurgy 16s, Ore-Dressing Lab., 6, Met. 13w, 15w
Metallurgy 107s, Precious Metals, 4, Met. 106w
Metallurgy 155s, Metallography, 7, Met. 154w
Mining Engineering 6s, Mine-Mapping, 6, Min. Eng. 5w
Metallurgy 21s, Field Work in Metallurgy beginning about May 1, 10 days, satisfactory completion of junior year
Mining 5s, Field Work in Mine Plant and Mining beginning about May 10, 2 weeks, satisfactory completion of junior year

SENIOR YEAR

First Quarter

Electrical Engineering 41f, Electric Power, 5, Phys. 5s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Mechanics 17f, Water Power, 7, Mech. 9f
Metallurgy 6f, Ore-Testing, 2, Met. 107s
Metallurgy 7f, Ore-Testing Lab., 8, Met. 107s
Metallurgy 108f, Electrometallurgy, 3, Met. 107s
Metallurgy 18f, Thesis, 8

Second Quarter

Geology 112w, Petroleum, 3, Geol. 111f
Metallurgy 8w, Special Problems in Ore-Testing, 4, Met. 107s

Metallurgy 10w, Advanced Metallurgy, 10, Met. 107s
Metallurgy 19w, Thesis, 18, Met. 18f
Metallurgy 164w, Advanced Metallography, 3, Met. 155s, or
Geology 80w, Advanced Historical, 3, Geol. 73f

Third Quarter

Metallurgy 9s, Special Problems in Ore-Testing, 4, Met. 107s
Metallurgy 11s, Advanced Metallurgy, 10, Met. 107s
Metallurgy 20s, Thesis, 18, Met. 19w
Metallurgy 165s, Advanced Metallography, 3, Met. 155s, or
Geology 113s, Problems in Ore Deposits, 4, Geol. 112w

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags is shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace-room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their report in detail. This work is offered to students completing the necessary courses in mineralogy and chemistry.

ORE-DRESSING

The lectures and recitations in ore-dressing extend through the junior year, and comprise a detail study of ore-dressing and concentrating machinery, together with a study of typical combinations of dressing machines as found in the various mining districts of the United States. In connection with the theoretical work, the ore-dressing laboratory and testing plant of the school are utilized for illustration, and practical use of ore-dressing machinery.

ORE-TESTING

The lectures treat of the problems in ore-testing such as extraction and losses in roasting, concentration, and other milling operations. Both the ore-dressing laboratory and the Mines Experiment Station laboratory are available for working out practical problems. The Mines Experiment Station laboratory is the old Ore-Testing Works modified to aid the mining interests of the state of Minnesota in solving problems connected with concentration and conservation of the iron and manganiferous ores of the state.

The School of Mines laboratories therefore serve both educational and commercial needs.

Educational.—The student becomes familiar with the use of the various types of machines such as crushers, rolls, classifiers, concentration and flotation machinery.

Commercial.—The laboratories are used by the Mines Experiment Station to determine the best methods of treatment to produce a commercial product at the lowest cost. Recently additional commercial machinery has been obtained and new appliances are constantly being developed. Commercial samples varying from 500 pounds to car-load lots can be treated by various methods.

FIELD WORK IN METALLURGY

At the end of the junior year students are required to study practical operations at one or more smelters and mills. This begins about May 1. The expenses for this trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover board and lodging and necessary side trips. Any balance will be returned at the close of the work in the field.

All notes, data, and sketches, necessary for a complete report on the field work, must be fully and neatly recorded in notebooks. These notebooks will be collected at the close of the trip and returned to the student at the reopening of field work at the school. In judging the character of the student's field work equal importance will be given to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below standard.

Upon termination of the junior field work in metallurgy and two weeks in mining and mine plant (not later than June 1), the members of the junior class who are candidates for the degree of Metallurgical Engineer are urged to spend at least six weeks in practical work in one or more of the smelters or mills, for which they may receive wages. The department will render all possible assistance in locating students in districts of their choice.

Field work will reopen at the School of Mines, Tuesday, September 21, 1920. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in metallurgy and mining must be prepared at the School of Mines under the direct supervision of the

departments concerned. The program covering this work is as follows: metallurgy, September 21 to 28, inclusive; mining and mine plant, September 29 to October 12, inclusive.

On October 12, all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 12. These reports shall become the property of the school.

METALLOGRAPHY

Courses in metallography are offered to candidates for the degree of Metallurgical Engineer in the School of Mines, to students in the Colleges of Dentistry, Engineering and Architecture, Science, Literature, and the Arts, in the School of Chemistry, and in the Graduate School.

These courses deal with the study of metals and alloys. The lectures treat of and describe the apparatus used in connection with this subject, the method of preparing specimens, physical and metallographic principles involved, and the interpretation of the results of microscopic examination and thermal analysis. There is an elaborate file of references and abstracts relating to the whole field of metallography, furnishing up-to-date information on the various phases of the work. A collection of specimens, photomicrographs, and lantern slides covering wrought iron, low-carbon structural, rail, and tool steels, brasses, bronzes, and other industrial alloys is available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals and alloys. The laboratories are equipped with grinding and polishing apparatus, microscopes, photomicrographic apparatus, vacuum electric furnace, carbon resistance furnaces, nichrome and platinum resistance furnaces of various designs, gas furnaces, heat-treating furnace, and pyrometers of the latest and improved types. There is a special darkroom for the preparation of photomicrographs.

DEPARTMENTAL STATEMENTS

EXPLANATION OF COURSE NUMBERS

The suffixes f, w, or s, indicate the quarter in which a course is offered, e.g., fall, winter, or spring quarters respectively. More than one suffix indicates that a course is offered in each of the corresponding quarters. No suffix indicates that the time of taking a course is to be arranged with the departments concerned.

All undergraduate courses are numbered from 1 to 100. All courses open to undergraduates and graduates are numbered from 101 to 200. Strictly graduate courses are numbered from 201 up.

CHEMISTRY

Professors Lauder W. Jones, Charles F. Sidener; Associate Professor M. Cannon Sneed; Assistant Professor Isaac W. Geiger.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	General Inorg. Chemistry.....	3	4	All fr.	....
2w	General Inorg. Chemistry.....	3	4	All fr.	1f
3s	General Inorg. Chemistry.....	3	4	All fr.	2w
11f	Qualitative Chem. Analysis.....	3	4	All soph.	3s
20w	Quantitative Chem. Analysis.....	1	7	All soph.	11f
123f	Iron and Steel Analysis.....	1	6	Jr. Geol.	20w
124w	Mineral and Ore Analysis.....	1	6	Jr. Geol.	20w

1f. General Inorganic Chemistry. A beginning course in chemistry. A study of the general laws of chemistry and of the non-metals and their compounds.

2w. General Inorganic Chemistry. A continuation of Course 1f.

3s. General Inorganic Chemistry. A study of the metals and their compounds. A continuation of Course 2w.

11f. Qualitative Chemical Analysis. Laboratory work in systematic qualitative analysis with lectures on solution, ionization, chemical and physical equilibrium, oxidation and reduction, and other subjects pertinent to qualitative analysis.

20w. Quantitative Chemical Analysis. An introductory course covering the general principles and methods of quantitative analysis, both gravimetric and volumetric. Typical problems will be assigned and attention given to proper laboratory practice. Sidener, Geiger, and Assistants.

123f. Iron and Steel Analysis. The rapid technical methods for the determination of the common constituents of iron ore. Iron and steel will be discussed and compared, and typical problems assigned for laboratory practice. Sidener, Geiger, and Assistants.

124w. Mineral and Ore Analysis. A course in the rapid technical methods for the determination of important constituents in minerals, ores, and slags. Sidener, Geiger, and Assistants.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor William H. Kirchner; Assistant Professor Robert W. French; Instructors Leon Archibald, Howard D. Myers, Orrin W. Potter.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11f	Engineering Drawing	0	10	All fr.	....
12w	Engineering Drawing	0	8	All fr.	11f
13s	Engineering Drawing	0	8	All fr.	12w
14f	Descriptive Geometry	3	0	All soph.	13s, Math. 5s
15w	Drafting	0	4	All soph.	14f

11f. Engineering Drawing. Sketching, lettering, representation, elements of drafting, details of machines and structures, interpretation of working drawings. Kirchner, Archibald.

12w. Engineering Drawing. Continuation of Course 11f. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Kirchner, Archibald, Potter.

13s. Engineering Drawing. Continuation of Course 12w. The elements of general drafting. Maps and sketches. Brush and pen conventions. Kirchner, Archibald, Potter.

14f. Descriptive Geometry. Projection; central and special cases, principles and application, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. Kirchner.

15w. Drafting. Graphics, machine drafting, and structural drafting. Instruction in drafting-room methods. Archibald, Potter.

ELECTRICAL ENGINEERING

Professor George D. Shepardson; Associate Professor William T. Ryan.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
41f	Electric Power.....	2	3	Sr. E.M.	Physics 5s

41f. Electric Power. Elementary principles of continuous currents. Continuous current generators and motors. Elementary principles of alternating currents. Alternating current generators, transformers,

and motors. Measurement of power. Elementary principles of transmission and distribution. Lectures, recitation, laboratory work. RYAN.

EXPERIMENTAL ENGINEERING

Professors WILLIAM E. BROOKE; Associate Professors WILLIAM F. HOLMAN, FRANK B. ROWLEY, CHARLES F. SHOOP; Instructor BURTON J. ROBERTSON.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
M.E. 83.4f	Elementary Laboratory	..	4	Jr. E.M.	With Mech. 12f
M. & M. 43.2w	Materials Testing Lab.	..	4	Jr. E.M.	With Mech. 10w
M.E. 184.1w	Experimental Lab.....	..	4	Sr. E.M.	M.E. 83.4f

M.E.83.4f. ELEMENTARY LABORATORY. Calibrations of thermometer, gages, weirs, nozzle, orifices, and meters. Efficiency of machines, friction of belting, friction tests, burning point, chill point, viscosity and specific gravity of oils. Tests of water motors, rams, and pulsometers.

M.&M.43.2w. MATERIALS TESTING LABORATORY. Investigation of physical properties of metals and engineering materials: wood, cement, ropes, etc., supplemented by lectures on materials of construction and methods of testing. BROOKE, HOLMAN.

M.E.184.1w. EXPERIMENTAL LABORATORY. Indicator practice, valve-setting, separating and throttling calorimeter, tests of steam engine, gas engine, pump, air compressor, turbine, boiler, and power plant. ROWLEY, SHOOP.

GEOLOGY AND MINERALOGY

Professors WILLIAM H. EMMONS, CLINTON R. STAUFFER, FRANK F. GROUT; Assistant Professors A. WALFRED JOHNSTON, THOMAS M. BRODERICK; Instructors CARL O. DUNBAR; ARTHUR J. TIEJE.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1w	General Geology	3	..	All soph.	105f
2s	General Geology	3	4	All soph.	105f
18w	Elem. of Paleontology.....	3	..	Elective	....
19s	Elem. of Paleontology.....	3	..	Elective	....
23f	Elem. of Mineralogy.....	4	4	All fr.	....
24w	Elem. of Mineralogy.....	2	2	All fr.	....
25s	Elem. of Mineralogy.....	4	4	All fr.	....
41f	Paleontology	3	..	Sr.E.M.(Geol.)	2s
42w	Paleontology	3	..	Sr.E.M.(Geol.)	2s
43s	Paleontology	3	..	Sr.E.M.(Geol.)	2s
61f	Physical Mineralogy	2	4	Elective	25s
65f	Crystallography	2	4	Elective	25s
73f	Econ. Geology	3	..	All jr.	2s, 105f

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
80w	Advanced Hist. Geology	3	..	Sr.E.M.&Met.E.	73f
85	Summer Field Work	..	2 wks.	All soph.	28
101f	Principles of Stratigraphy	3	..	Elective	25s
105f	Elem. of Rock Study	..	4	All soph.	25s
106w	Petrography	..	4	All soph.	105f
111f	Ore Deposits	3	..	All sr.	73f, 106w
112w	Geology of Petroleum	3	..	All sr.	111f
113s	Problems in Ore Deposits	..	4	All sr.	112w
124w	Struct. & Metamorph. Geol	3	..	Jr.E.M.(Geol.)	73f, 105f
125s	Struct. & Metamorph. Geol	6	..	Jr.E.M.(Geol.)	73f, 105f
131f	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
132w	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
133s	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
137w	Testing Econ. Minerals	1	4	Sr.E.M.(Geol.)	73f
140w	Applied Petrography	1	4	Sr.E.M.(Geol.)	111f, 13s
141s	Applied Petrography	1	4	Sr.E.M.(Geol.)	111f, 13s
144w	Construction and Interpretation of Geologic Maps	..	6	Jr.E.M.(Geol.)	73f
145s	Construction and Interpretation of Geologic Maps	..	12	Jr.E.M.(Geol.)	73f
150s	Field Geology	..	..	Jr.E.M.(Geol.)	125s
151f	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
152w	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
153s	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
166w	Mineralography	..	6	Sr.E.M.(Geol.)	111f
167s	Mineralography	..	6	Sr.E.M.(Geol.)	111f
246	Pre-Cambrian Geology	3	3	Elective	125s
247	Geol. and Exploration of Lake Superior Region	3	..	Elective	125s

1w, 2s. General Geology. A synoptical treatment of materials of the earth, and of geologic processes. Physiographic, dynamic, structural, and historical geology. Johnston.

18w, 19s. Elements of Paleontology. An introduction to the study of fossil organisms. Lectures supplemented by field excursions. Stauffer.

23f, 24w, 25s. Elements of Mineralogy. The crystal systems; morphological, physical, chemical characters of minerals; occurrence, genesis, and uses of minerals; classifications and description of common minerals; rock minerals, and common rocks. Determinative work in the laboratory, blowpipe analysis, sight identification. Grout, Broderick.

41f-42w-43s. Paleontology. A study of fossil forms with special reference to those of geologic importance; faunas and their correlation. Stauffer.

61f. Physical Mineralogy. The form, optical and physical properties of minerals; expansion and conductivity; pyro-electricity; hardness, percussion, and etch figures; cleavage and gliding planes. Broderick.

65f. Crystallography. Projection and geometric relations of crystal planes; crystal nomenclature; the relation of special properties to

morphology. A study of crystal models, crystal drawing, identification of minerals from crystal measurements, and mathematical calculation. BRODERICK.

73f. ECONOMIC GEOLOGY. Study of non-metallic minerals of economic value, and discussions of geologic guides to prospecting for these deposits.

80w. ADVANCED HISTORICAL GEOLOGY. The sequence of events in geologic history, of interest to the advanced student in mining. STAUFFER.

85s. FIELD WORK. About two weeks in June are spent in geologic mapping of selected areas in the iron district of Minnesota. Involves preparation of geologic maps and written reports. JOHNSTON.

101f. PRINCIPLES OF STRATIGRAPHY. Origin and structure of sedimentary deposits; the interpretation of these in relation to paleogeography; field work in connection with Cambrian and Ordovician problems. TIEJE.

105f. ELEMENTS OF ROCK STUDY. The occurrence and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. GROUT, BRODERICK.

106w. PETROGRAPHY. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and metamorphic rocks. The origin and classification of rocks. GROUT, BRODERICK.

111f. ORE DEPOSITS. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. EMMONS.

112w. GEOLOGY OF PETROLEUM. The nature, origin, and accumulation of petroleum; discussion of the various oil fields of the world. EMMONS.

113s. PROBLEMS IN ORE DEPOSITS. Field excursions, map work, lectures on field and laboratory methods. EMMONS.

124w, 125s. STRUCTURAL AND METAMORPHIC GEOLOGY. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. JOHNSTON.

131f, 132w, 133s. ADVANCED PETROLOGY. Advanced optical methods. Criteria for rapid indentification of minerals and rocks. The uses of schedules and tables. Standard rock types. Regional and genetic studies. Petrographic reports. GROUT.

137w. TESTING ECONOMIC MINERALS. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, oil, building stone, and metallic ores. GROUT.

140w, 141s. Applied Petrography. Determination of ores and gangue minerals. Microscopic studies of paragenesis of ores and other mineral associations. Practical problems in mining and geology settled by microscopic and optical examinations. Grout.

144w, 145s. Construction and Interpretation of Geologic Maps. Methods of geologic examination; problems in construction and interpretation of geologic maps and sections.

150s. Field Geology. Detailed, systematic work conforming with standards of official surveys. Preparation of geological maps, structure sections, reports; paragenesis of ores and their relations to geologic structures. Field for 1920, Black Hills, South Dakota. Reports to be written week before college opens in fall. Emmons, Johnston.

151f, 152w, 153s. Advanced General Geology. Geologic processes and their results; development of the North American continent. Stauffer.

166w, 167s. Mineralography. Methods of studying opaque minerals and the application of the methods to problems in ore genesis and history. Broderick.

246. Pre-Cambrian Geology. The problems of pre-Cambrian correlation and structure; the pre-Cambrian stratigraphy of North America. Given in alternate years. Johnston.

247. Geology and Exploration of Lake Superior Region. The geology of the Lake Superior iron districts. Methods used in the exploration of iron ore; interpretation of drill cores; cartographic expressions of drill data; models of drilled areas. Principles of magnetic surveying. Johnston.

GERMAN

Professor Carl Schlenker; Assistant Professors James Davies, Samuel Kroesch, Walter R. Myers; Instructor Lynwood Downs.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
*4f, 5w, 6s	Beginning	3	Jr.E.M.(Geol.)	....
7f	Intermediate	3	Jr.E.M.(Geol.)	4-5-6 or equiv.
15f	Narrative Prose	4	Elective	2 yrs. prep.
*25w, 26s	Elementary Scientific	3	Elective	7
*28w, 29s	Advanced Chemical	3	Elective	15

* All quarters must be completed before credit is given in any one quarter.

4f-5w-6s. Beginning for Miners. Pronunciation, grammar, conversation; selected readings in easy prose. Schlenker, Downs.

7f. Intermediate for Miners. Continuation of Course 4-5-6.

15f. Narrative Prose. Reading, grammar review. Kroesch, Downs.

25w, 26s. Elementary Scientific. Readings from simple expository German. Selections from works on chemistry. Davies, Downs.

28w, 29s. Advanced Chemical German. Selections from more difficult works on chemistry. Schlenker, Myers.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Associate Professor Oscar E. Harder; Instructors Ralph L. Dowdell, Elwyn L. Smith.

COURSES

No.	Title	Lec. hrs.	Lab. hrs.	Required of	Prerequisite courses
1w	Assaying	4	..	All fr.	Chem. 1f, Geol. 23f
2w	Assaying Lab.	..	8	All fr.	Chem. 1f, Geol. 23f
3f	General Metallurgy	3	..	Soph.E.M.&Met.E.	1w, 2w, Chem. 3s
4w	Metallurgy of Pig Iron	3	..	Soph.E.M.&Met.E.	3f
5s	Met. Wrought Iron and Steel	3	..	Soph.E.M.&Met.E.	4w
6f	Ore-Testing	2	..	Sr.E.M.&Met.E.	107s
7f	Ore-Testing Lab.	..	8	Sr.E.M.&Met.E.	107s
8w	Spec. Prob. in Ore-Test.	..	4	Sr.E.M.&Met.E.	107s
9s	Spec. Prob. in Ore-Test.	..	8	Sr.E.M.&Met.E.	107s
10w	Advanced Metallurgy	4	6	Sr.Met.E.	107s
11s	Advanced Metallurgy	4	6	Sr.Met.E.	107s
12f	Ore-Dressing	3	..	All jr.	Phys. 5s, Geol. 25s
13w	Ore-Dressing	3	..	All jr.	Met. 12f, 14f
14f	Ore-Dressing Lab.	..	4	Jr.Met.E.	Phys. 5s, Geol. 25s
15w	Ore-Dressing Lab.	..	4	Jr.Met.E.	Met. 12f, 14f
16s	Ore-Dressing Lab.	..	6	Jr.Met.E.	Met. 13w, 15w
17s	Ore-Dressing Lab.	..	6	Jr.E.M.&E.M.Geol.	Met. 13w
18f	Thesis in Metallurgy	..	8	Sr.Met.E.	Satisfactory completion of jr. year
19w	Thesis in Metallurgy	..	18	Sr.Met.E.	18f
20s	Thesis and Specifications	..	18	Sr.Met.E.	19w
21s	Field Work in Met.	..	**	Jr.Met.E.	Same as 18f
22w	Mechanical Technology	3	..	Mech. Engineers	.....
105f	Met. of Base Metals	4	..	Jr.E.M.&Met.E.	3f
106w	Met. of Base Metals	4	..	Jr.E.M.&Met.E.	105f
107s	Met. of Precious Metals	4	..	Jr.E.M.&Met.E.	106w
108f	Electrometallurgy	3	..	Sr.Met.E.	107s
153f	Mphy., Long Course	3	4	Jr.Met.E.	Chem. 20w, Phys. 5s
154w	Mphy., Long Course	3	4	Jr.Met.E.	153f
155s	Mphy., Long Course	3	4	Jr.Met.E.	154w
156w	Mphy. for Engineers	2	4	Elective	.....
157s	Adv. Mphy. for Engrs.	2	4	Elective	156w
159f	Dental Metallography	3	..	Elective	.....
160s	Mphy. for Chemists	2	3	Jr. Chem.	Chem. 20w
161f	Adv. Mphy. for Chem.	2	3	Elective	160s
162w	Adv. Mphy. for Chem.	2	3	Elective	160s

** Ten days.

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
163f	Adv. Metallography.....	To be ar	Elective		153f, 154w, 155s, or equivalent
164w	Adv. Metallography.....	To be ar	Elective		.....
165s	Adv. Metallography.....	To be ar	Elective		.....
201f	Adv. Mphy., Gr. students	To be ar	Elective		.....
202w	Adv. Mphy., Gr. students	To be ar	Elective		.....
203s	Adv. Mphy., Gr. students	To be ar	Elective		.....

1w. ASSAYING. The determination of values of ores, metallurgical products by the fire method. Lectures and recitations. APPLEBY, CHRISTIANSON.

2w. ASSAY LABORATORY. Practical determination of gold, silver, lead, and tin by the fire method. CHRISTIANSON, PEASE, SMITH.

3f. GENERAL METALLURGY. Combustion, fuels, refractory materials, furnaces and fluxes. Lectures and recitations. CHRISTIANSON.

4w. METALLURGY OF PIG IRON. General principles of iron blast furnace practice. Construction of furnace, handling of stock, and products, principles of regulation. Lectures and recitations. CHRISTIANSON.

5s. METALLURGY OF WROUGHT IRON AND STEEL. General principles involved in the production of wrought iron and steel. Lectures and recitations. CHRISTIANSON.

6f. ORE-TESTING. General principles involved in determining the best method of extraction, including amalgamation, concentration, cyanidation, roasting, etc. Lectures and recitations. CHRISTIANSON.

7f. ORE-TESTING LABORATORY. Practical determination of extraction and distribution of values in mill and metallurgical products. Methods of calculation. CHRISTIANSON and Assistants.

8w. SPECIAL PROBLEMS IN ORE-TESTING. Continuation of Course 7f. Practical determinations for regulating metallurgical operations. PEASE.

9s. SPECIAL PROBLEMS IN ORE-TESTING. Continuation of Course 8w. PEASE.

10w. ADVANCED METALLURGY. Pyrometry, calorimetry, and metallurgical calculations to determine heat balance and heat distribution. Lectures and laboratory work. CHRISTIANSON.

11s. ADVANCED METALLURGY. Design of furnaces, conferences and laboratory work. CHRISTIANSON.

12f. ORE-DRESSING. Crushing, sizing, classification, and concentration of ores. Lectures and recitations. SMITH.

13w. ORE-DRESSING. Continuation of Course 12f. SMITH.

14f. ORE-DRESSING LABORATORY. Practical examination of ores and the use of ore-dressing machinery. SMITH.

15w. Practical Problems in Ore-Dressing. Smith.

16s. Ore-Dressing Laboratory. Continuation of Course 15w. Smith.

17s. Ore-Dressing Laboratory. Short course in the laboratory use of ore-dressing machinery. Smith.

18f. Thesis in Metallurgy. Conferences to select suitable problem together with preliminary laboratory work on problem selected. Christianson.

19w. Continuation of Course 18f. Christianson.

20s. Completion of thesis including specifications covering installation of a plant. Christianson.

21s. Field Work in Metallurgy. Study of metallurgical operations at smelters and mills. Detail reports are required covering plants visited. Christianson, Pease.

22w. Mechanical Technology. Lectures on mining, metallurgy, and treatment of metals used in construction. Christianson, Pease.

105f. Metallurgy of the Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining. Lectures and recitations. Pease.

106w. Metallurgy of Base Metals. Continuation of Course 105f. Pease.

107s. Metallurgy of the Precious Metals. Principles involved and methods used in the extraction of gold, silver, and other precious metals. Lectures and recitations. Pease.

108f. Electrometallurgy. Application of electricity to production of heat for smelting ores and refining metals. Costs of fuel and electricity for heating, relative efficiencies of electric and fuel furnaces. Construction of high-temperature furnaces and commercial plants. Christianson.

153f, 154w, 155s. Metallography. (Long course for Metallurgical Engineers.) Theory of metallic alloys. Metallographic technic. Properties of metals and alloys. Metallography of iron and steel and commercial alloys. Technical metallography. Laboratory work. Harder, Dowdell.

156w. Metallography for Engineers. Principles of metallography, including pyrometry, thermal analysis, constitution diagrams, microscopic and photomicrographic technique; metallography and heat treatment of iron and steel. Laboratory work. Harder, Dowdell.

157s. Advanced Metallography for Engineers. Continuation of 156w. Metallography of alloy steels, tool steels, high-speed tool steels, and important non-ferrous alloys; metallography applied to engineering

practice and specifications. Outside reading and special reports. Laboratory work. HARDER, DOWDELL.

159f. DENTAL METALLOGRAPHY. Study of the dental alloys from the standpoint of metallography. HARDER.

160s. METALLOGRAPHY FOR CHEMICAL STUDENTS. Metallography, including constitution diagrams, preparation and standardization of thermocouples, preparation and thermal analysis of alloys, their microscopic examination and making photomicrographs; typical alloy systems such as iron-carbon (steel and cast iron); some non-ferrous alloys. Laboratory work. HARDER, DOWDELL.

NOTE: This course will be offered in both the fall and spring quarters in 1920-21.

161f. ADVANCED METALLOGRAPHY FOR CHEMICAL STUDENTS. Metallography and heat treatment of iron and steel, including alloy steels, commercial uses of various steels, and engineering specifications. Laboratory work. HARDER, DOWDELL.

162w. ADVANCED METALLOGRAPHY FOR CHEMICAL STUDENTS. Metallography of the non-ferrous metals with a study of the constitution diagrams, properties, and uses of important commercial alloys. Laboratory work. HARDER, DOWDELL.

163f, 164w, 165s. ADVANCED METALLOGRAPHY. Technical and scientific research. The study of steel rails, automobile and locomotive parts, tool steels, etc. Special problems in metallography with outside reading. Seminar work on the recent advances in metallography. HARDER.

201f, 202w, 203s. ADVANCED METALLOGRAPHY FOR GRADUATE STUDENTS. Intended primarily for research work. HARDER.

MILITARY SCIENCE AND TACTICS

Professor ALBERT G. GOODWYN, Captain, Infantry, U.S.A., Chairman; Assistant Professors BEN W. FEILD, Captain, Infantry, U.S.A.; LAURENCE T. WALKER, Captain, C.A.C., U.S.A.; LEE R. WATROUS, JR., Captain, C.A.C., U.S.A.; EDGAR B. MOOMAU, 1st Lieutenant, Infantry, U.S.A.; HARVEY G. THOMAS, 1st Lieutenant, U.S.A., Retired; Instructors JOEL R. BAKER, Master Signal Electrician, Signal Corps, U.S.A.; ALFRED BRANDT, Regimental Sergeant Major, Infantry, U.S.A.; HENRY W. BROWN, Sergeant, Coast Artillery Corps, Unassigned, U.S.A.; KENNA B. CALDWELL, Sergeant, Coast Artillery Corps, Unassigned, U.S.A.; AUBREY R. DUNKUM, 1st Sergeant, Coast Artillery Corps, Unassigned, U.S.A.; WILLIAM FINKE, 1st Sergeant, Coast Artillery Corps, Unassigned, U.S.A.; JOSEPH HAVLICEK, Regimental Commissary Sergeant, Infantry, U.S.A., Retired; WILLIAM L. HOGAN, 1st Sergeant, Coast

Artillery Corps, Unassigned, U.S.A.; INGVALD M. JOHNSON, 1st Sergeant, Infantry, Unassigned, U.S.A.; JOSEPH LEES, 1st Sergeant, Infantry, U.S.A., Retired; JOHN MCWILLIAMS, 1st Sergeant, Infantry, U.S.A., Retired; WILLIAM G. PALMS, Sergeant, Infantry, Unassigned, U.S.A.

COURSES

No.	Title	Hrs.	Required of	Prereq. courses
1	First-year Basic Course R.O.T.C.	3	†All fr.	None
2a	Second-year Basic Course R.O.T.C., Infantry	3	*Soph.	1
2b	Second-year Basic Course R.O.T.C., Coast Artillery	3	Soph.	1
2c	Second-year Basic Course R.O.T.C., Signal Corps	3	Soph.	1

* Work in military science and tactics for sophomores will open on Friday, September 17, at 8:30 a.m., and continue for ten days. Satisfactory completion of Course 2a, 2b, or 2c at that time is required of all sophomores.

This course applies only to sophomores, who are required to leave the following May 1 for field work.

† Must be legally eligible for enrollment in Reserve Officers' Training Corps.

MINE PLANT AND MECHANICS

Professor ELTING H. COMSTOCK; Assistant Professor ANDERS J. CARLSON; Instructor JAMES C. SANDERSON.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	Algebra and Solid Geometry	6	..	B fr.	..
2f	Algebra	6	..	A fr.	..
3s	Algebra	4	..	B fr.	1f
4w	Trigonometry	6	..	All fr.	..
5s	Analytical Geometry	6	..	All fr.	4w
6f	Calculus	4	..	All soph.	5s
7w	Calculus	3	..	All soph.	6f
8s	Calculus	6	..	All soph.	7w
9f	Mechanics	5	..	Jr.E.M.&Met.E.	8s
10w	Mechanics of Materials	5	..	Jr.E.M.&Met.E.	9f
11s	Mechanics of Materials	5	..	Jr.E.M.&Met.E.	10w
12f	Mine Plant	6	..	Jr.E.M.&Met.E.	8s
13w	Mine Plant	6	..	Jr.E.M.	12f
14s	Mine Plant	6	..	Jr.E.M.	13w
15w	Metallurgical Plant	3	..	Jr.Met.E.	12f
16s	Metallurgical Plant	3	..	Jr.Met.E.	15w
17f	Hydraulics and Water-Power	5	2	Sr.E.M.&Met.E.	9f
18f	Engineering Construction	..	8	Sr.E.M.	11s
19w	Mine Plant Design	..	9	Sr.E.M.	18f
20s	Mine Plant Design	..	12	Sr.E.M.	19w

1f. ALGEBRA AND SOLID GEOMETRY. Equations, involution and evolution, theory of exponents, surds, quadratic equation, theory of logarithms,

determinants. Demonstrations of most important theorems of solid geometry. Volumes, approximate volumes, prismoidal formula, etc. SANDERSON.

2f. ALGEBRA. Functions, functional notation, factor and remainder theorems, factors and values of functions, development of functions, progressions, series, theory of equations, permutations and combinations, theory of logarithms, determinants. COMSTOCK, SANDERSON.

3s. ALGEBRA. Continuation of 1f. Functions, functional notation, factor and remainder theorems, factors and values of functions, development of functions, progressions, series, theory of equations, permutations and combinations. SANDERSON.

4w. TRIGONOMETRY. Trigonometric ratios, right triangles, definitions of trigonometric functions, analytic relations, trigonometric equations, etc., solution of spherical triangles. COMSTOCK, SANDERSON.

5s. ANALYTICAL GEOMETRY. Systems of coördinates, loci, equations, properties of straight line, transformation of coördinates, equations and properties of conics, equations of second degree, higher plane curves, space coördinates, point, plane, quadric surfaces, etc., empirical equations, graphic algebra. SANDERSON.

6f, 7w, 8s. CALCULUS. Differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, indeterminate forms, partial derivatives, change of variable, elementary integration, undetermined coefficients, rationalization, formulas of reduction, some differential equations of mechanics. SANDERSON.

9f. MECHANICS. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy. CARLSON.

10w, 11s. MECHANICS OF MATERIALS. Mechanical and elastic properties of materials of construction; beams, columns, shafts, hollow cylinders and spheres, rollers, plates; theory of internal stress; reinforced concrete. CARLSON.

12f, 13w, 14s. MINE PLANT. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, rock drills, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. COMSTOCK.

15w, 16s. METALLURGICAL PLANT. Power, air, and water supply for metallurgical plants. COMSTOCK.

17f. HYDRAULICS AND WATER-POWER. Laws of the equilibrium, pressure and flow of liquids, estimation of power to be developed at a power

site, dams and appendages, theory of water wheels and turbines, speed control, power-house equipment, transmission. CARLSON.

18f. ENGINEERING CONSTRUCTION. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures, design of mining structures. CARLSON.

19w, 20s. MINE PLANT DESIGN. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. COMSTOCK.

MINING

Associate Professor WALTER H. PARKER.

COURSES

No.	Title	Lect. or rec. hrs.	Lab. hrs.	Required of	Prerequisite courses
1s	Introductory Mining	4	..	All soph.	..
2f	Exploration	5	..	All jr.	1s
3w	Tunneling	5	..	All jr.	2f
4s	Mining Methods	5	..	All jr.	3w
5s	Practical Mining	..	2 wks.	All jr.	Satisfactory completion of jr. yr.
6f	First Aid	..	*	All jr.	..
51f	Mine Rescue	..	*	All sr.E.M.&E.M.(Geol.)	..
52f	Mining Reports	5	..	All sr.E.M.&E.M.(Geol.)	4s
53w	Mining Problems	5	..	All sr.E.M.&E.M.(Geol.)	52f
54s	Mining Law	5	..	All sr.E.M.&E.M.(Geol.)	53w
55f	Thesis	..	2	All sr.E.M.	4s
56w	Thesis	..	12	All sr.E.M.	55f
57s	Thesis	..	12	All sr.E.M.	56w

* 15 hours (1 week).

1s. INTRODUCTORY MINING. Introductory mining course, preparatory to sophomore field trip. PARKER.

2f. EXPLORATION. Occurrence of ore-bodies, prospecting, exploration, boring, explosives, blasting, and quarrying. PARKER.

3w. TUNNELING. Explosives, drilling, tunneling, drifting, shaft-sinking and raising. PARKER.

4s. MINING METHODS. Underground mining methods and support of underground excavations. PARKER.

5s. PRACTICAL MINING. Study of mining operations. Mine plant and mining work in one or more mining camps. PARKER, COMSTOCK.

6f. FIRST AID. Course in first aid to the injured, given by the staff of the United States Bureau of Mines car.

51f. MINE RESCUE. Course in mine rescue, given by the staff of the United States Bureau of Mines car.

52f. Mining Reports. Preparation of one or more mining reports, from data supplied by the mining department; open-pit work, quarrying, placer mining, hydraulic mining and dredging. Parker.

53w. Mining Problems. Coal mining methods, mine drainage, mine ventilation, mine transportation, mine sanitation, mine hygiene, cost accounting, and mine examination. Parker.

54s. Mining Law. Course in mining law, mine management and economics of mining. Parker.

55f. Thesis. Preparatory work on the mining thesis. Parker.

56w. Thesis. Preparation of an original thesis on some mining project, covering the exploration and development of a mining property. Parker.

57s. Thesis. Completion of thesis project. Parker.

MINING ENGINEERING

Associate Professor Edwin M. Lambert.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	Mine Surveying	3	..	All soph.	Math. 4w
2w	Mine Surveying	3	..	All soph.	1f
3s	Mine Surveying	3	4	All soph.	2w
4s	Field Work	..	7 wks.	All soph.	3s
5w	Mine Mapping	..	6	All jr.	4s
6s	Mine Mapping	..	6	All jr.	5w

1f-2w-3s. Mine-Surveying. Theory and problems in mine-surveying including land subdivision, stadia measurements, triangulation, railroad curves and cross-sections, computation of areas by coördinates; differential leveling, topographic map reading, solar observations, shaft plumbing, underground traversing and leveling. Lambert.

4s. Field Work. Practice in general plane surveying during the month of May. Practice in underground surveying during the first three weeks of June. This work is given on the iron ranges of Minnesota. Lambert, Carlson.

5w-6s. Mine-Mapping. Mine-mapping in accordance with prevalent practice in mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. Carlson.

PHYSICS

Professors Henry A. Erikson, Anthony Zeleny; Professorial Lecturer Louallen F. Miller.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
23f	Elements of Mechanics	3	..	All soph.	Math. 5s
24f	Mechanics Laboratory	..	2	All soph.	With 23f
43w	Heat	3	..	All soph.	23f
44w	Heat Laboratory	..	2	All soph.	24f and with 43w
63s	Magnetism and Electricity	3	..	All soph.	23f
64s	Magnetism and Electricity Lab.	..	2	All soph.	24f and with 63s

23f. Elements of Mechanics and Sound. Mechanics of solids, fluids, wave motion, and sound. A study of the simpler fundamental principles. First part of a general Course 23, 43, 53, 63. Course 24 should be taken in conjunction with this course. Erikson.

24f. Elements of Mechanics and Sound Laboratory. Measurements in the mechanics of solids, fluids, wave motion, and sound; the laboratory part supplementing Course 23. One two-hour session in the laboratory a week. Erikson.

43w. Heat. A study of the principles underlying heat phenomena. Course 44 should be taken in conjunction with this course. Miller.

44w. Heat Laboratory. The laboratory part supplementing Course 43. One two-hour session in the laboratory a week. Miller.

63s. Magnetism and Electricity. A study of the principles underlying magnetic and electric phenomena. Course 62 should be taken in conjunction with this course. Zeleny.

64s. Electrical Laboratory. The laboratory part supplementing Course 63. One two-hour session in the laboratory a week. Zeleny.

ROMANCE LANGUAGES

Professors Everett W. Olmsted, Irville C. Le Compte, Colbert Searles; Associate Professors Ruth S. Phelps, Edward H. Sirich; Assistant Professors Francis B. Barton, Jules T. Frelin.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
*4-5	Beginning French	5	Jr.E.M.(Geol.)	....
6-7	Intermediate French	5	Elective	4-5
*30-31-32	Survey French Lit.	3	Elective	6-7
*204-205	Beginning Spanish	5	Jr.E.M.(Geol.)	....
206-207	Intermediate Spanish	5	Elective	204-205
*230-231-232	Spanish Literature	3	Elective	206-207

* All quarters must be completed before credit is given in any one quarter.
Note: Beginning and intermediate courses are offered every quarter.

4, 5. Beginning French. Stress on accurate pronunciation, reading, reading vocabulary, and the essentials of grammar. Daily oral and written exercises (dictation and reproduction in French).

6, 7. Intermediate French. French grammar, composition, and reading; increased use of French in the classroom. Selections from modern prose and poetry.

30, 31, 32. General Survey of French Literature. Lectures, recitations, and assigned readings. Designed to cover the whole period in historical outline. Selections from representative authors.

204, 205. Beginning Spanish. Pronunciation, grammar, oral exercises and translation.

206, 207. Intermediate Spanish. Review of grammar, composition, conversation, and reading.

230, 231, 232. Spanish Literature. Discussions based upon texts and collateral reading.

STUDENTS

1919-1920

SENIORS—16

Ainsworth, Robert E., Minneapolis
Arnold, Lewis E., Minneapolis
Bailey, A. K., Jr., Minneapolis
Barr, J. Carroll, Jr., Pittsburgh, Pa.
Clark, Fred E., Minneapolis
Copeland, William A., St. Paul
Donaghue, Abner J., Minneapolis
Edwin, John, Minneapolis
Frank, Harry O., Minneapolis
Johnson, Axel L., Benson
Kersten, Erwin H., Minneapolis
Mark, Israel C., Minneapolis
Nichols, Clifford R., Buhl
Peterson, Clarence D., Minneapolis
Raiter, Clifford R., Minneapolis
Wheeler, James D., Minneapolis

JUNIORS—20

Abramson, Jake, Minneapolis
Butler, Roy G., Beaver Dam, Wis.
Carlson, Edwin N., Brainerd
Chadbourn, Charles H., Minneapolis
Dawson, Loren W., Minneapolis
Flom, Frank, Minneapolis
Frank, Elden J., Duluth
Gandrud, Bennie W., Glenwood
Hamernik, F. J., Menominee, Mich.
Hope, Lawrence I., Minneapolis
Johnsen, Trygve, St. Paul
Johnston, Kenneth A., St. Paul
Nicholls, William J., Ely
Rydlun, Edward G., Minneapolis
Sebenius, Carl H., Duluth
Sponberg, Edwin C., Hibbing
Walz, C. M., Gladstone, Mich.
Wenger, Frank B., Grand Rapids, Mich.
West, Herbert S., Minneapolis
Zanger, Eugene, Minneapolis

SOPHOMORES—36

Adams, Maurice, Moorhead
Alger, Leon J., Staples
Anderson, Oscar B., Crosby
Barker, Clifton T., Excelsior
Brenner, Walter W., Minneapolis
Chang, Chen Ping, Nanking, China
Clay, J. Withers, Minneapolis
Echebarria, Luis de Uribe, Bilbao, Spain
Friedl, Arthur J., St. Paul
Gray, Donald U., Fergus Falls
Gross, Forrest C., Duluth
Gustafson, Arnold A., Duluth
Hansen, Mayer G., Minneapolis
Heathcote, William O., Duluth
Henkel, H. L., Minneapolis
Hoffman, Louis, Minneapolis
Johnson, Ralph C., Bemidji
Kilp, Raymond, Minneapolis
Kwong, Shou-Kun, Shanghai, China
Le Roy, James, Minneapolis
Lin, Sze Chen, Peking, China
Lovering, Thomas S., St. Paul
McKenzie, Frederick R., Adrian
Mannerberg, Walter F., Minneapolis
Merrill, J. W., St. Paul
Moga, Gregory M., St. Paul
Olson, Alvin B., Bemidji
Patten, Richard C., Minneapolis
Plut, Frank J., Crosby
Ridgway, R. H., Mandan, N. Dak.
Schied, Adolph J., Milwaukee, Wis.
Siverson, Garfield C., Minneapolis
Smith, Lyle W., Minneapolis
Thoeni, Victor T., Wykoff
Webster, W. H., Minneapolis
Wilson, J. Byron, Minneapolis

FRESHMEN—87

Allen, A. W., Minneapolis
Allen, Laurin L., Minneapolis
Anderson, Alfred, Crosby
Apuli, Waine E., Mountain Iron
Ballard, John A., Minneapolis
Barker, J. H., Minneapolis
Blair, J. V., Winona
Beckwith, Gerald H., Blanca, Colo.
Brawley, John, St. Paul
Brooke, Clinton L., Minneapolis
Butler, Robert V., St. Paul
Case, Carlos C., Minneapolis
Case, Leslie M., Minneapolis
Cavanaugh, A. M., Duluth
Clement, Charles J., Proctor
Conhaim, Howard J., St. Paul
Dains, H. F., Jr., Minneapolis
DeVaney, Fred D., Minneapolis

Dinmore, Harry C., Jr., St. Paul
Dunham, W. C., Anaheim, Cal.
Erdman, Charles, Minneapolis
Erickson, Arthur C., Virginia
Foss, Adolph Lee, Frazee
Gallagher, Luke J., Faribault
Gerber, William A., St. Paul
Gordon, Morris E., Minneapolis
Gow, Alexander M., Duluth
Grabau, E. L., Bonair, Iowa
Graeber, Clyde, Minneapolis
Greenberg, Arnold N., St. Paul
Griswold, Harland, Duluth
Griswold, W. R., Duluth
Grover, Willard A., Winona
Gudmundson, Staney L., Minneota
Hall, H. C., Minneapolis
Hawlik, Hartley H., Silver Lake
Henderson, Philip J., Excelsior
Hezzlewood, George W., Minneapolis
Jeffers, G. D., Cresco, Iowa
Jelinek, Fred M., New Prague
Jensen, Willard C., Minneapolis
Johnstone, George, Minneapolis
Jones, John B., Minneapolis
Kegler, Vern L., Minneapolis
Knutson, Clarence J., Little Falls
Larsen, Raymond M., Duluth
Latendresse, Henry E., Red Lake Falls
Levy, Julian H., St. Paul
Liddicoat, Roy H., Biwabik
Lilly, Richard J., St. Paul
Linstrom, John H., Minneapolis
Lucas, John J., Minneapolis
Lundquist, O. William, Two Harbors
Lust, Harold W., Minneapolis
Middleton, John L., Marshall
Mooney, Frank E., St. Paul
Murphy, Fred M., Virginia
Opdahl, Carl, Sheldon, N. Dak.
Pabst, Henry Adam, Hibbing
Person, Virgil H., Minneapolis
Queneau, Roland B., Minneapolis
Roberts, Paul E., Freeborn
Russell, Charles B., Winton
Searles, John N., Mazeppa
Segal, Julius, Minneapolis
Sieux, Joseph, Chicago, Ill.
Sjolinder, Anthony O., St. Paul
Smith, Donald K., Minneapolis
Smith, Wayland H., Minneapolis
Stewart, James L., Minneapolis
Strunk, William, Minneapolis
Sundeen, Ludvig J., Litchfield
Swenson, Clifford H., Braham
Thellin, Herbert E., Crosby
Thompson, Harry S., St. Paul
Tollefson, Everett H., Mabel
Trulander, William, Minneapolis
Vivian, Edgar, Duluth
Wachtel, Dean E., Duluth
Weeks, Merwyn B., Detroit
Wilcox, Fred H., Minneapolis
Winter, Morse W., Winona
Wolfer, Donald H., St. Paul
Wrbitzky, Harry M., Silver Lake
Wright, Donald R., Luverne

UNIVERSITY CALENDAR

1921-1922

1921			
September	16	Friday	Sophomores, School of Mines, report for military drill, 8:30 a.m.
September	17	Saturday	Payment of fees closes, except for new students
September	20	Tuesday	Juniors and seniors, School of Mines, report for completion of field work
September	23-27	Week	Examinations for removal of conditions and entrance examinations; see below
September	26-27		Registration days
September	27	Tuesday	Payment of fees for new students closes
September	28	Wednesday	Fall quarter begins, 8:30 a.m.
October	20	Thursday	Senate meeting, 4:30 p.m.
November	24	Thursday	Thanksgiving Day; a holiday
December	15	Thursday	Senate meeting, 4:30 p.m.
December	21	Wednesday	Fall quarter ends, Christmas vacation begins, 5:20 p.m.
1922			
January	4	Wednesday	Christmas vacation ends, winter quarter begins, 8:30 a.m.
February	16	Thursday	Senate meeting, 4:30 p.m.
February	22	Wednesday	Washington's Birthday; a holiday
March	23	Thursday	Winter quarter ends, spring vacation begins, 5:20 p.m.
March	29	Wednesday	Spring vacation ends, spring quarter begins, 8:30 a.m.
May	1	Monday	Field work for sophomores and juniors in School of Mines begins
May	18	Thursday	Senate meeting, 4:30 p.m.
May	30	Tuesday	Memorial Day; a holiday
June	11	Sunday	Baccalaureate service
June	13	Tuesday	Spring quarter closes, 5:20 p.m.
June	14	Wednesday	Fiftieth annual commencement
June	17-19		Registration days for summer session
June	20	Tuesday	Summer session begins
July	29	Saturday	Summer session closes

Program of Supplementary Examinations

Friday,	Sept. 23	9-12 a.m.	Physics
		2-5 p.m.	Chemistry, experimental engineering
Saturday,	Sept. 24	9-12 a.m.	Mathematics and mechanics
		2-5 p.m.	Drawing and descriptive geometry
Monday,	Sept. 26	9-12 a.m.	Metallurgical subjects
		2-5 p.m.	Electric power
Tuesday,	Sept. 27	9-12 a.m.	Geology and mineralogy
		2-5 p.m.	Mining subjects

THE SCHOOL OF MINES

FACULTY

Lotus Delta Coffman, Ph.D., President
William Watts Folwell, LL.D., President Emeritus
Cyrus Northrop, LL.D., President Emeritus
William R. Appleby, M.A., Dean, and Professor of Metallurgy
Thomas M. Broderick, Ph.D., Assistant Professor of Geology
Anders J. Carlson, C.E., Assistant Professor of Mine Plant and Mechanics
Peter Christianson, B.S., E.M., Professor of Metallurgy
Elting H. Comstock, M.S., Professor of Mine Plant and Mechanics
James Davies, Ph.D., Assistant Professor of German
William H. Emmons, Ph.D., Professor of Geology and Mineralogy
Henry A. Erikson, B.E.E., Ph.D., Professor of Physics
Robert W. French, B.S. in C.E., Assistant Professor of Drawing and Descriptive Geometry
Isaac W. Geiger, Ph.D., Assistant Professor of Chemistry
Frank F. Grout, M.S., Ph.D., Professor of Geology and Mineralogy
Oscar E. Harder, Ph.D., Associate Professor of Metallography
Ralph House, Ph.D., Associate Professor of Romance Languages
William H. Kirchner, B.S., Professor of Drawing and Descriptive Geometry
Raymond E. Kirk, M.S., Assistant Professor of Chemistry
Edwin M. Lambert, M.E., Associate Professor of Mining Engineering
Irville C. LeCompte, Ph.D., Professor of Romance Languages
Louallen F. Miller, B.S., M.A., Professorial Lecturer in Physics
Everett W. Olmsted, Ph.D., Professor of Romance Languages
Walter H. Parker, E.M., Associate Professor of Mining
Levi B. Pease, M.S., Professor of Metallurgy
Ruth S. Phelps, M.A., Associate Professor of Romance Languages
William T. Ryan, E.E., Associate Professor of Electrical Engineering
Frank B. Rowley, M.E., Professor of Mechanical Engineering and Director of Experimental Engineering Laboratories
James C. Sanderson, Ph.D., Assistant Professor of Mine Plant and Mechanics
Carl Schlenker, B.A., Professor of German
Colbert Searles, Ph.D., Professor of Romance Languages
George D. Shepardson, M.A., M.E., D.Sc., Professor of Electrical Engineering
Charles F. Shoop, B.S., Associate Professor of Mechanical Engineering
Charles F. Sidener, B.S., Professor of Chemistry
M. Cannon Sneed, Ph.D., Associate Professor of Chemistry
Clinton R. Stauffer, B.S., Ph.D., Professor of Geology
Girard Sturtevant, Colonel, Infantry, U.S.A., Professor of Military Science and Tactics

Anthony Zeleny, M.S., Ph.D., Professor of Physics
Ira S. Allison, B.A., Instructor in Geology
Leon Archibald, B.S., Instructor in Drawing and Descriptive Geometry
Ralph L. Dowdell, Met.E., Instructor in Metallography
John W. Gruner, B.A., M.S., Instructor in Geology
Louis S. Heilig, E.M., Instructor in Mining
Erwin H. Kersten, E.M., Instructor in Metallurgy
Cowden Laughlin, Ph.D., Instructor in German
Norville C. Pervier, M.S., Instructor in Chemistry
Orrin W. Potter, M.E., Instructor in Drawing and Descriptive Geometry
Burton J. Robertson, E.E., Instructor in Experimental Engineering
Landon A. Sarver, M.A., Instructor in Chemistry
George M. Schwartz, M.A., Instructor in Geology
Elwyn L. Smith, B.S., Instructor in Metallurgy
George W. Swenson, B.S. in E.E., Instructor in Electrical Engineering
George A. Thiel, M.A., Instructor in Geology
W. Courtney Werner, B.A., Instructor in Geology
H. B. Wilcox, B.S., M.A., Instructor in Mathematics and Mechanics
Elizabeth B. Henderson, Librarian

GENERAL INFORMATION

The School of Mines was established by the Board of Regents in 1888, upon recommendation of the general faculty of the University. The buildings and laboratories of the school are located on the main campus of the University. The mining districts of Minnesota are within a few hours, by rail, of Minneapolis. The heartiest coöperation exists between the various mine managements and the school, so that the mining properties are at all times open to parties from the school for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts. Students in the School of Mines have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

The School of Mines occupies the new building provided by the Legislature of 1913. In the basement are the assay and electro-metallurgical laboratories, together with machinery room, instrument room, balance-room, furnace-rooms, and necessary storerooms. On the first floor are the administrative offices, and offices and lecture-rooms of the departments of Metallurgy and Mine Plant and Mechanics. On the second floor are the offices, lecture-rooms, and drafting-rooms of the Department of Mining, the ore-dressing laboratory, and the library of the school. On the third floor are the offices, laboratories, and lecture-rooms of the Department of Metallography, the Department of Mining Engineering, junior drafting-room, photographic darkrooms, blue-printing room, and offices and computing rooms for the branch of the experiment station serving the tax commission.

DEGREES

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degrees of Engineer of Mines (E.M.), Engineer of Mines in Geology [E.M.(Geology)], and Metallurgical Engineer (Met.E.) respectively.

The degree of Metallurgical Engineer may be conferred upon a candidate who received the degree of Engineer of Mines in four years, and vice versa, provided such candidate completes an additional year's work at the school and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and Architecture, and in the School of Chemistry, who contemplate taking a degree in this school after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thoro courses in mechanics, mathematics, surveying, physics, chemistry,

and the necessary theory and practice of structural, mechanical, and electrical engineering.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine whether or not it has value for treatment. (d) *Mining engineering*—to furnish material for treatment. (e) *Mine Plant*—to provide the physical equipment for mining and treating the ore. (f) *Ore-testing*—to determine best methods of treatment. (g) *Ore-dressing*—to furnish products for metallurgical treatment. (h) *Metallurgy*—to smelt and refine ores and ore-dressing products; reduction to metals. (i) *Metallography*—to study metals and their alloys.

EXPERIMENT STATION

The School of Mines Experiment Station has been recently established to promote the development of the mining and mineral resources of the state; to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the tax commission, and to do such other work along the lines above outlined as may be requested by other state departments. Coöperation has been effected with the United States Bureau of Mines, the United States Geological Survey, the Minnesota Geological Survey, and the School of Chemistry.

The experiment station is prepared to assist citizens interested in these lines of work, and to assay specimens of ore, rocks, clays, and minerals found within the state, free of charge.

In submitting samples the sender must state the exact location in which each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the office of the station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, the University of Minnesota, Minneapolis, Minnesota.

ADMISSION

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology), and Metallurgical Engineer may be completed in four years.

Freshmen will be divided into two sections as follows:

a. Those entering with credits in higher algebra and solid geometry.

b. Those entering without credits in higher algebra and solid geometry. Students in section b will carry a special course in mathematics during their freshman year.

Details as to admission and entrance requirements, description of subjects accepted for admission, and list of fees and expenses will be found in the bulletin of general information, which will be sent to any address upon application to the registrar, the University of Minnesota, Minneapolis.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

ADMISSION TO ADVANCED STANDING

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrolment Committee of the School of Mines.

FEES

Tuition fees (per quarter)	
Residents of Minnesota	$30.00
Non-residents	40.00
Deposit (first quarter only)	5.00
Military deposit (required of all students taking drill)	10.00
Minnesota Union (per quarter)	1.00
Post-office box (per quarter)	.20
Special fees	
Examination for removal of condition	1.00
Examinations for credit (after the first six weeks in residence)	5.00
Special examinations	5.00
Chemistry deposit	5.00

Penalty Fees

Registration penalties.—A penalty fee for late registration, late change of registration, or late payment of fees shall be two dollars ($2.00) and one dollar ($1.00) additional for each day of delay after classes begin, provided that no student shall pay more than twelve dollars ($12.00) of penalty in any given quarter.

GRADUATION

Students completing courses of study to the satisfaction of the faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examination in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least the full year be spent at the University

before such degree shall be granted, and provided the examination in every case be held before a committee of the faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examination for the third quarter. Irregular attendance will debar a student from entering all final examinations.

THESIS

The thesis work is intended to bring in review and connect the work in mining and metallurgy, geology and mineralogy, mechanical and electrical engineering, mathematics and mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of Engineer of Mines; the investigation of a problem in mining geology, for candidates for the degree of Engineer of Mines (in Geology); and the investigation of a metallurgical problem, for candidates for the degree of Metallurgical Engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of field work at the School of Mines, Tuesday, September 20, 1921, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 30. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the school.

SPECIAL NOTES

Students failing to receive a quarter mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the registrar his average in all subjects and present himself for supplementary examinations, according to the program on page 3.

Failure of the registrar to notify a student of deficiencies will not be accepted as a reason for neglecting to report for necessary supplementary examinations. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for these subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining, mining engineering, and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

Students failing to receive a quarter mark of 50 per cent in any subject shall not be allowed to pursue any dependent subject.

The faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination for any quarter will be given zero on the examinations.

Students whose absences in any quarter exceed 20 per cent of the scheduled class hours will not be permitted to take examinations without special permission of the faculty.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

During the academic year students will be held responsible for the receipt of official communications sent to them through the University post-office. During the summer vacation they will be held responsible for the receipt of such communications sent to the home address given on registration blank for the preceding academic year, unless formal notification of their correct address is filed with the registrar and the dean.

COURSES OF STUDY

UNIFORM CURRICULUM TO END OF SOPHOMORE YEAR

The courses leading to the degrees of Engineer of Mines, Engineer of Mines (in Geology), and Metallurgical Engineer are uniform for the first two years.

Freshmen will be divided into two sections as follows:

a. Those entering with credits in advanced algebra and solid geometry.

b. Those entering without credits in advanced algebra and solid geometry.

Subjects with the prefix a are to be taken by freshmen in section a; those with the prefix b are to be taken by freshmen in section b; and those without prefix are to be taken by students of both sections.

FRESHMAN YEAR

First Quarter

Chemistry 4f or 14f,* General Inorganic, 6 or 9†
Drawing 11f, Engineering Drawing, 10
a. Mathematics 2f, Algebra, 6
b. Mathematics 1f, Algebra and Solid Geometry, 6
Geology 23f, Elements of Mineralogy, 8
Military Drill

Second Quarter

Chemistry 5w or 15w, General Inorganic, 6 or 9, Chem. 4f or 14f
Drawing 12w, Engineering Drawing, 8, Draw. 11f
Mathematics 4w, Trigonometry, 6
Metallurgy 1w, Assaying, 4, Chem. 4f or 14f, Geol. 23f
Metallurgy 2w, Assaying Laboratory, 8, Chem. 4f or 14f, Geol. 23f
Geology 24w, Elements of Mineralogy, 4, Geol. 23f
Military Drill

Third Quarter

Chemistry 16s, Qualitative Analysis, 9, Chem. 5w or 15w
Drawing 13s, Engineering Drawing, 8, Draw. 12w
Mathematics 5s, Analytical Geometry, 6, Math. 4w
b. Mathematics 3s, Algebra, 4, Math. 1f
Geology 25s, Elements of Mineralogy, 8, Geol. 24w
Military Drill

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* The suffixes f,w, or s, after the course number indicate the quarter in which a course is offered—fall, winter, or spring quarter respectively. Two or three suffixes indicate that a course is offered in each of the corresponding quarters.

† Figure following the descriptive name of a course indicates number of hours per week. Course names following indicate prerequisite courses.

SOPHOMORE YEAR

First Quarter

Drawing 14f, Descriptive Geometry, 3, Draw. 13s, Math. 5s
Geology 105f, Rock Study, 4, Geol. 25s
Mathematics 6f, Calculus, 4, Math. 5s
Metallurgy 3f, General, 3, Met. 1w, 2w, Chem. 16s
Mining Engineering 1f, Mine-Surveying, 3, Math. 4w
Physics 3f, Elements of Mechanics, 3, Math. 5s
Physics 4f, Mechanics Laboratory, 2, Math. 5s
Military Science and Tactics, 2a, 2b, or 2c

Work in military science and tactics for sophomores will open on Friday, Sept. 16 at 8:30 a.m., and continue for ten days. Satisfactory completion of Course 2a, 2b, or 2c, at that time is required of all sophomores. This course applies only to sophomores who are required to leave the following May 1 for field work.

Second Quarter

Chemistry 28w, Quantitative Analysis, 8, Chem. 16s
Drawing 15w, Drafting, 4, Draw. 14f
Geology 1w, General, 3, Geol. 105f
Geology 106w, Petrography, 4, Geol. 105f
Mathematics 7w, Calculus, 3, Math. 6f
Metallurgy 4w, Met. of Pig Iron, 3, Met. 3f
Mining Engineering 2w, Mine-Surveying, 3, Min. Eng. 1f
Physics 23w, Heat, 3, Phys. 3f
Physics 24w, Heat Laboratory, 2, Phys. 4f

Third Quarter

Geology 2s, General, 7, Geol. 105f
Mathematics 8s, Calculus, 6, Math. 7w
Metallurgy 5s, Wrought Iron and Steel, 3, Met. 4w
Mining 1s, Introductory Mining, 4
Mining Engineering 3s, Mine-Surveying, 7, Min. Eng. 2w
Physics 43s, Magnetism and Electricity, 3, Phys. 3f
Physics 44s, Magnetism and Elec. Lab., 2, Phys. 4f

Mining Engineering 4s, Field Work beginning about May 1, 7 weeks, Min. Eng. 3s
Geology 85, Field Work beginning about June 20, 2 weeks, Geol. 2s
Underground Mining Work beginning about July 5

JUNIOR AND SENIOR YEARS

COURSES LEADING TO THE DEGREE OF ENGINEER OF MINES

JUNIOR YEAR

First Quarter

Experimental Engineering, M.E. 84f, Elementary Lab. 4, with Mech. 12f
Geology 73f, Economic, 3, Geol. 2s, 105f
Mechanics 9f, Mechanics, 5, Math. 8s

Mechanics 12f, Mine Plant, 6, Math. 8s
Metallurgy 105f, Base Metals, 4, Met. 3f
Metallurgy 12f, Ore-Dressing, 3, Phys. 43s, Geol. 25s
Mining 2f, Exploration, 5, Mining 1s
Mining 6f, First Aid, 1 week

Second Quarter

Experimental Engineering, M. & M. 144w, Materials-Testing Lab., 4, with Mech. 10w
Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mechanics 13w, Mine Plant, 6, Mech. 12f
Metallurgy 106w, Base Metals, 4, Met. 105f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f
Mining 3w, Tunneling, 5, Mining 2f
Mining Engineering 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Mechanics 11s, Mechanics of Materials, 5, Mech. 10w
Mechanics 14s, Mine Plant, 6, Mech. 13w
Metallurgy 107s, Precious Metals, 4, Met. 106w
Metallurgy 17s, Ore-Dressing Lab., 6, Met. 13w
Mining 4s, Mining Methods, 5, Mining, 3w
Mining Engineering 6s, Mine-Mapping, 6, Min. Eng. 5w
Metallurgy 21s, Field Work in Metallurgy beginning about May 1, 10 days, satisfactory completion of junior year
Mining 5s, Field Work in Mine Plant and Mining beginning about May 1, 2 weeks, satisfactory completion of junior year

SENIOR YEAR

First Quarter

Electrical Engineering 41f, Electric Power, 5, Phys. 43s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Mechanics 17f, Water Power, 7, Mech. 11s
Mechanics 18f, Engineering Construction, 8, Mech. 11s
Metallurgy 6f, Ore-Testing, 2, Met. 107s
Metallurgy 7f, Ore-Testing Lab. 8, Met. 107s
Mining 52f, Mining Methods, 5, Mining 4s
Mining 51f, Mine Rescue, 1 week
Mining 55f, Thesis, 2, Mining 4s

Second Quarter

Experimental Engineering, M.E., 181w, Advanced Lab., 4, Exp. Eng. M.E. 84f
Geology 112w, Petroleum, 3, Geol. 111f
Geology 80w, Advanced Historical, 3, Geol. 73f
Mechanics 19w, Mine-Plant Design, 9, Mech. 18f
Metallurgy 8w, Special Problems, 4, Met. 107s
Mining 53w, Mine Management, 5, Mining 52f
Mining 56w, Thesis, 12, Mining, 55f

Third Quarter

Geology 113s, Problems in Ore Deposits, 4, Geol. 112w
Mechanics 20s, Mine-Plant Design, 12, Mech. 19w
Metallurgy 9s, Special Problems, 8, Met. 107s
Mining 54s, Mine Administration, 5, Mining 53w
Mining 57s, Thesis, 12, Mining 56w

DEPARTMENT OF MINING

The Department is well supplied with samples of the smaller mine equipment, models, drawings, photographs, lantern slides, and mine maps. The lectures treat of prospecting, development, support of excavations, mining methods, mine administration, mining law, and the necessary allied subjects. The courses in mining extend through the sophomore, junior, and senior years.

FIELD WORK IN MINING

JUNIOR YEAR

At the end of the junior year students are required to study mine plant and mining methods in one or more mining districts under the direction of members of the faculty. This work begins about May 1, and not over three weeks will be devoted to it. The work is carried on in the leading western metal-mining districts, the exact location to be announced in April of each year. The expenses for the trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover board and lodging and necessary side trips. Any balance will be returned at the close of the work in the field.

All notes, data, and sketches, necessary for a complete report on the field work, must be fully and neatly recorded in notebooks. These notebooks will be collected at the close of the trip and returned to the student at the reopening of field work at the school. In judging the character of the student's field work equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below the standard that should be demanded of candidates for senior work. During the months of June, July, and August, the student is urged to spend at least six weeks in actual underground mining work in the West for which he may receive wages. The department will render all possible assistance in locating students in districts of their choice.

Field work will reopen at the School of Mines, Tuesday, September 20, 1921. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in Mining and Metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned: Metallurgy, September 20 to 27, inclusive; Mining and Mine Plant, September 28 to October 11, inclusive.

On October 11 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 11. These reports shall become the property of the school.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reason, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

DEPARTMENT OF MINING ENGINEERING

MINE-SURVEYING

The work in surveying is given in the sophomore year and is designed primarily for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning with the first Monday in May, the class devotes seven weeks to field work at some convenient point on the Mesabi, Cuyuna, or Vermilion Range. The exact location will be announced in March of each year. The expenses for this trip are estimated at $150.

The students will be divided into squads of two to four. Each student will be required to complete satisfactorily a practical course in plane and underground surveying including exercises in chaining and taping; adjustment and use of surveying instruments; solar and stellar observations; laying out railroad tangents and curves; making earthwork estimates; and other problems. In addition each squad will be required to make a yardage estimate of the stripping of an open-pit mine; to transfer a meridian, from the surface, underground and make a complete survey of an underground mine.

The data obtained will be used in the course in mine-mapping during the winter quarter of the junior year.

A full equipment of surveying instruments of the latest and best types is furnished each squad for this work.

Courses Leading to the Degree of Engineer of Mines (in Geology)

JUNIOR YEAR

First Quarter

Geology 61f or 65f, Blowpipe Analysis or Crystallography, 6, Geol. 25s
Geology 73f, Economic, 3, Geol. 2s, 105f
Geology 131f, Advanced Petrology, 6, Geol. 2s, 106w
Geology 151f, Advanced General, 3, Geol. 73f

German 4f or 7f, or French 1 or 21, or Spanish 1 or 65, 5 or 3
Mining 2f, Exploration, 5, Min. 1s
Mining 6f, First Aid, 1 week
Electives, 3

Second Quarter

Geology 124w, Struct. and Metamorphic, 3, Geol. 73f, 105f
Geology 132w, Advanced Petrology, 6, Geol. 2s, 106w
Geology 144w, Geologic Maps, 6, Geol. 73f
Geology 152w, Advanced General, 3, Geol. 73f
German 5w or 25w, or French 2w or 22w, or Spanish 2w or 66w, 5 or 3
Mining 3w, Tunneling, 5, Min. 2f
Mining Engineering 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Geology 125s, Struct. and Metamorphic, 6, Geol. 73f, 105f
Geology 133s, Advanced Petrology, 6, Geol. 2s, 106w
Geology 145s, Geologic Maps, 12, Geol. 73f
Geology 153s, Advanced General, 3, Geol. 73f
Mining 4s, Mining Methods, 5, Min. 3w
Geology 150s, Field Work in Geology beginning about May 1, six weeks, Geol. 125s
Geologic Field Work beginning about June 15 with geological surveys or private companies

SENIOR YEAR

First Quarter

Geology 91f, Paleontology, 3, Geol. 2s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Metallurgy, 12f, Ore-Dressing, 3, Phys. 5s, Geol. 25s
Mining 52f, Mining Methods, 5, Min. 4s
Mining 51f, Mine Rescue, 1 week
Thesis, 8
Electives, 6

Second Quarter

Geology 92w, Paleontology, 3, Geol. 2s
Geology 112w, Petroleum, 3, Geol. 111f
Geology 137w, Testing Economic Materials, 5, Geol. 73f
Geology 140w, Applied Petrography, 5, Geol. 111f, 13s
Geology 166w, Mineralography, 6, Geol. 111f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f
Mining 53w, Mine Management, 5, Min. 52f
Thesis, 3

Third Quarter

Geology 93s, Paleontology, 3, Geol. 2s
Geology 113s, Problems in Ore Deposits, 4, Geol. 112w

Geology 141s, Applied Petrography, 5, Geol. 111f, 13s
Geology 167s, Mineralography, 6, Geol. 111f
Metallurgy 17s, Ore-Dressing Lab., 6, Met. 13w
Thesis, 10

FIELD WORK IN GEOLOGY

At the end of the sophomore year mining students are required to devote about three weeks to geologic mapping. This course usually comes after a seven weeks' course in surveying and the fields chosen are the Vermilion and Mesabi iron ranges of Minnesota. This work is intended to train the students in the interpretation of field relations and the preparation of geologic maps and cross-sections.

The second field course in geology is required only of those students who are candidates for the Engineer of Mines (in Geology) degree. The course begins early in May and is completed in June. The course requires altogether about six weeks' work, and the field chosen is the Black Hills region of South Dakota or some other western region. The student is trained in the interpretation of field data; in detailed mapping, underground and on the surface; in the preparation of geologic cross-sections through mines; and he may gather material which will serve as a basis for future study in advanced courses the following year. The work conforms to the standards of official surveys as nearly as practicable. At the close of the field season the students are expected to obtain positions with mining companies either as miners or as engineers, or if openings are available, they may enter geological surveys for the season's work.

Field work in geology for students having taken either of the above trips will reopen at the School of Mines, Tuesday, September 20, 1921. The final reports covering the field work must be prepared at the School of Mines under the direct supervision of the Department of Geology. These reports are to be turned in to the department on September 27.

Courses Leading to the Degree of Metallurgical Engineer

JUNIOR YEAR

First Quarter

Geology 73f, Economic, 3, Geol. 2s, 105f
Mechanics 9f, Mechanics, 5, Math. 8s
Mechanics 12f, Mine Plant, 6, Math. 8s
Metallurgy 12f, Ore-Dressing, 3, Phys. 43s, Geol. 25s
Metallurgy 14f, Ore-Dressing Lab., 4, Phys. 43s, Geol. 25s
Metallurgy 105f, Base Metals, 4, Met. 3f
Metallurgy 153f, Metallography, 7, Chem. 28w, Phys. 43s
Mining 6f, First Aid, 1 week

Second Quarter

Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mechanics 15w, Metallurgical Plant, 3, Mech. 12f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f, 14f

Metallurgy 15w, Ore-Dressing Lab., 4, Met. 12f, 14f
Metallurgy 106w, Base Metals, 4, Met. 105f
Metallurgy 154w, Metallography, 7, Met. 153f
Mining Engineering, 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Mechanics 11s, Mechanics of Materials, 5, Mech. 10w
Mechanics 16s, Metallurgical Plant, 3, Mech. 15w
Metallurgy 16s, Ore-Dressing Lab., 6, Met. 13w, 15w
Metallurgy 107s, Precious Metals, 4, Met. 106w
Metallurgy 155s, Metallography, 7, Met. 154w
Mining Engineering 6s, Mine-Mapping, 6, Min. Eng. 5w
Metallurgy 21s, Field Work in Metallurgy beginning about May 1, 10 days, satisfactory completion of junior year
Mining 5s, Field Work in Mine Plant and Mining beginning about May 1, 2 weeks, satisfactory completion of junior year

SENIOR YEAR

First Quarter

Electrical Engineering 41f, Electric Power, 5, Phys. 43s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w, or
Mechanics 18f, Engineering Construction, 8, Mech. 11s
Mechanics 17f, Water Power, 7, Mech. 11f
Metallurgy 6f, Ore-Testing, 2, Met. 107s
Metallurgy 7f, Ore-Testing Lab., 8, Met. 107s
Metallurgy 108f, Electrometallurgy, 3, Met. 107s
Metallurgy 18f, Thesis, 8
Mining 51f, Mine Rescue, 1 week

Second Quarter

Geology 112w, Petroleum, 3, Geol. 111f, or
Mechanics 19w, Mine-Plant Design, 9, Mech. 18f
Metallurgy, 8w, Special Problems in Ore-Testing, 4, Met. 107s
Metallurgy 10w, Advanced Metallurgy, 10, Met. 107s
Metallurgy 19w, Thesis, 18, Met. 18f
Metallurgy 164w, Advanced Metallography, 3, Met. 155s, or
Geology 80w, Advanced Historical, 3, Geol. 73f, or
Mining 53w, Mine Management, 5, Mining 52f

Third Quarter

Metallurgy 9s, Special Problems in Ore-Testing, 4, Met. 107s
Metallurgy, 11s, Advanced Metallurgy, 10, Met. 107s
Metallurgy 20s, Thesis, 18, Met. 19w
Metallurgy 165s, Advanced Metallography, 3, Met. 155s, or
Geology 113s, Problems in Ore Deposits, 4, Geol. 112w, or
Mining 54s, Mine Administration, 5, Mining 53w

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in metallurgy extends through three years.

ASSAYING

The lectures treat of and describe apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags is shown, and instruction is given as to nature and quantity of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace-room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their report in detail. This work is offered to students completing the necessary courses in mineralogy and chemistry.

ORE-DRESSING

The lectures and recitations in ore-dressing extend through the junior year, and comprise a detail study of ore-dressing and concentrating machinery, together with a study of typical combinations of dressing machines as found in the various mining districts of the United States. In connection with the theoretical work, the ore-dressing laboratory and testing plant of the school are utilized for illustration, and practical use of ore-dressing machinery.

ORE-TESTING

The lectures treat of the problems in ore-testing such as extraction and losses in roasting, concentration, and other milling operations. Both the ore-dressing laboratory and the Mines Experiment Station laboratory are available for working out practical problems. The Mines Experiment Station laboratory is the old Ore-Testing Works modified to aid the mining interests of the state of Minnesota in solving problems connected with concentration and conservation of the iron and manganiferous ores of the state.

The School of Mines laboratories therefore serve both educational and commercial needs.

Educational.—The student becomes familiar with the use of the various types of machines such as crushers, rolls, classifiers, concentration and flotation machinery.

Commercial.—The laboratories are used by the Mines Experiment Station to determine the best methods of treatment to produce a commercial product at the lowest cost. Recently additional commercial machinery has been obtained and new appliances are constantly being developed. Commercial samples varying from 500 pounds to car-load lots can be treated by various methods.

FIELD WORK IN METALLURGY

At the end of the junior year students are required to study practical operations at one or more smelters and mills. This begins about May 1. The expenses for this trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover board and lodging and necessary side trips. Any balance will be returned at the close of the work in the field.

All notes, data, and sketches, necessary for a complete report on the field work, must be fully and neatly recorded in notebooks. These notebooks will be collected at the close of the trip and returned to the student at the reopening of field work at the school. In judging the character of the student's field work equal importance will be given to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below standard.

Upon termination of the junior field work in metallurgy and two weeks in mining and mine plant (not later than June 1), the members of the junior class who are candidates for the degree of Metallurgical Engineer are urged to spend at least six weeks in practical work in one or more of the smelters or mills, for which they may receive wages. The department will render all possible assistance in locating students in districts of their choice.

Field work will reopen at the School of Mines, Tuesday, September 20, 1921. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in metallurgy and mining must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: metallurgy, September 20 to 27, inclusive; mining and mine plant, September 28 to October 11, inclusive.

On October 11, all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 11. These reports shall become the property of the school.

METALLOGRAPHY

Courses in metallography are offered to candidates for the degree of Metallurgical Engineer in the School of Mines, to students in the Colleges of Dentistry, Engineering and Architecture, Science, Literature, and the Arts, in the School of Chemistry, and in the Graduate School.

These courses deal with the study of metals and alloys. The lectures treat of and describe the apparatus used in connection with this subject, the method of preparing specimens, physical and metallographic principles involved, and the interpretation of the results of microscopic examination and thermal analysis. There is an elaborate file of references and abstracts relating to the whole field of metallography, furnishing up-to-date information on the various phases of the work. A collection of specimens, photomicrographs, and lantern slides covering wrought iron, low-carbon structural, rail, and tool steels, brasses, bronzes, and other industrial alloys is available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals and alloys. The laboratories are equipped with grinding and polishing apparatus, microscopes, photomicrographic apparatus, vacuum electric furnace, carbon resistance furnaces, nichrome and platinum resistance furnaces of various designs, gas furnaces, heat-treating furnace, and pyrometers of the latest and improved types. There is a special darkroom for the preparation of photomicrographs.

DEPARTMENTAL STATEMENTS

EXPLANATION OF COURSE NUMBERS

The suffixes f, w, or s, indicate the quarter in which a course is offered, e.g., fall, winter, or spring quarters respectively. More than one suffix indicates that a course is offered in each of the corresponding quarters. No suffix indicates that the time of taking a course is to be arranged with the departments concerned.

All undergraduate courses are numbered from 1 to 100. All courses open to undergraduates and graduates are numbered from 101 to 200. Strictly graduate courses are numbered from 201 up.

CHEMISTRY

Professor Charles F. Sidener; Associate Professor M. Cannon Sneed; Assistant Professors Isaac W. Geiger, Raymond E. Kirk; Instructors Norville C. Pervier, Landon A. Sarver.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
4f	General Inorganic Chemistry.....	3	3	All fr.	4f
5w	General Inorganic Chemistry.....	3	3	All fr.	h.s. chem.
14f	General Inorganic Chemistry.....	3	6	All fr.	..
15w	General Inorganic Chemistry.....	3	6	All fr.	14f
16s	Qualitative Chemical Analysis ...	3	6	All fr.	5w or 15w
28w	Quantitative Chemical Analysis ..	1	7	All soph.	16s
123f	Iron and Steel Analysis.....	1	6	Elective	28w
124w	Mineral and Ore Analysis.....	1	6	Elective	28w

4f. General Inorganic Chemistry. Designed for those who have had one year of high-school chemistry. Includes a study of the general laws of chemistry and of the non-metals, the metals and their compounds. Mr. Kirk.

5w. General Inorganic Chemistry. A continuation of Course 4f. Mr. Kirk.

14f. General Inorganic Chemistry. For those who have had no high-school chemistry. Includes a study of the general laws of chemistry and of the non-metals, the metals, and their compounds. Mr. Pervier.

15w. General Inorganic Chemistry. A continuation of Course 6f. Mr. Pervier.

16s. Qualitative Analysis. Laboratory work in systematic qualitative analysis with lectures on solutions, ionization, chemical and physical equilibrium, oxidation and reduction, and other subjects pertinent to qualitative analysis. Mr. Kirk, Mr. Pervier.

28w. Quantitative Analysis. A short introductory course covering the general principles and methods of quantitative analysis, both gravimetric and volumetric. Typical problems are assigned and attention given to proper laboratory practice. Mr. Sidener, Mr. Geiger, Mr. Sarver.

123f. Iron and Steel Analysis. The rapid technical methods for the determination of the common constituents of iron ore. Iron and steel will be discussed and compared, and typical problems assigned for laboratory practice. Mr. Sidener, Mr. Geiger, and Assistants.

124w. Mineral and Ore Analysis. A course in the rapid technical methods for the determination of important constituents in minerals, ores, and slags. Mr. Sidener, Mr. Geiger, and Assistants.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor William H. Kirchner; Assistant Professor Robert W. French; Instructors Leon Archibald, Orrin W. Potter.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11f	Engineering Drawing	..	10	All fr.	....
12w	Engineering Drawing	..	8	All fr.	11f
13s	Engineering Drawing	..	8	All fr.	12w
14f	Descriptive Geometry	3	..	All soph.	13s, Math. 5s
15w	Drafting	..	4	All soph.	14f

11f. Engineering Drawing. Sketching, lettering, representation, elements of drafting, details of machines and structures, interpretation of working drawings. Mr. Kirchner, Mr. Archibald.

12w. Engineering Drawing. Continuation of Course 11f. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Mr. Kirchner, Mr. Archibald, Mr. Potter.

13s. Engineering Drawing. Continuation of Course 12w. The elements of general drafting. Maps and sketches. Brush and pen conventions. Mr. Kirchner, Mr. Archibald, Mr. Potter.

14f. Descriptive Geometry. Projection; central and special cases, principles and application, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. Mr. Kirchner.

15w. Drafting. Graphics, machine drafting, and structural drafting. Instruction in drafting-room methods. Mr. Archibald, Mr. Potter.

ELECTRICAL ENGINEERING

Professor GEORGE D. SHEPARDSON; Associate Professor WILLIAM T. RYAN; Instructor GEORGE W. SWENSON.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
41f	Electric Power	2	3	Sr.E.M.	Physics 43s

41f. ELECTRIC POWER. Elementary principles of continuous currents. Continuous current generators and motors. Elementary principles of alternating currents. Alternating current generators, transformers, and motors. Measurement of power. Elementary principles of transmission and distribution. Lectures, recitation, laboratory work. MR. RYAN.

EXPERIMENTAL ENGINEERING

Professor FRANK B. ROWLEY, Director of Laboratory; Instructor BURTON J. ROBERTSON, Assistant Director.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
M.E. 84f	Elementary Laboratory (General)	..	4	Jr. E.M.	With Mech. 12f
M.&M. 144w	Materials-Testing Laboratory	..	4	Jr. E.M.	With Mech. 10w
M.E. 181w	Advanced Laboratory (General)	..	4	Sr. E.M.	M.E. 84f

M.E. 84f. ELEMENTARY GENERAL LABORATORY. Calibration of thermometers, gages, weirs, nozzle orifices, and meters. Efficiency of machines, friction of belting, friction tests; burning point, chill point, viscosity and specific gravity of oils. Tests of water motor, rams, and pulsometers. MR. SHOOP.

M.&M. 144w. MATERIALS-TESTING LABORATORY. Investigation of physical properties of metals and engineering materials: wood, cement, ropes, etc., supplemented by lectures and materials of construction and methods of testing. Mining and metallurgical engineers. MR. WILCOX.

M.E. 181w. ADVANCED GENERAL LABORATORY. Indicator practice, valve-setting, separating and throttling calorimeters, tests of steam engines, gas engines, pumps, air compressors, blowers, turbines, boilers, and power plant. MR. ROWLEY, MR. SHOOP.

GEOLOGY AND MINERALOGY

Professors WILLIAM H. EMMONS, FRANK F. GROUT, CLINTON R. STAUFFER; Assistant Professor THOMAS M. BRODERICK; Instructors IRA S. ALLISON, JOHN W. GRUNER, GEORGE M. SCHWARTZ, GEORGE A. THIEL, W. COURTNEY WERNER.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1w	General Geology	3	..	All soph.	105f
2s	General Geology	3	4	All soph.	105f
19s	Elem. of Paleontology	3	..	Elective	....
23f	Elem. of Mineralogy	4	4	All fr.	....
24w	Elem. of Mineralogy	2	2	All fr.	23f
25s	Elem. of Mineralogy	4	4	All fr.	24w
51f	Blowpipe Analysis	2	4	Elective	25s
65f	Crystallography	2	4	Elective	25s
73f	Econ. Geology	3	..	All jr.	2s, 105f
86w	Advanced Hist. Geology	3	..	Sr.E.M.&Met.E	73f
85s	Summer Field Work	..	2 wks.	All soph.	2s
91f	Paleontology	3	..	Sr.E.M.(Geol.)	2s
92w	Paleontology	3	..	Sr.E.M.(Geol.)	2s
93s	Paleontology	3	..	Sr.E.M.(Geol.)	2s
101f	Principles of Stratigraphy	3	..	Elective	25s
105f	Rock Study	..	4	All soph.	25s
106w	Petrography	..	4	All soph.	105f
111f	Ore Deposits	3	..	All sr.	73f, 106w
112w	Geology of Petroleum	3	..	All sr.	111f
113s	Problems in Ore Deposits	..	4	All sr.	112w
124w	Struct. & Metamorph. Geol.	3	..	Jr.E.M.(Geol.)	73f, 105f
125s	Struct. & Metamorph. Geol.	6	..	Jr.E.M.(Geol.)	73f, 105f
131f	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
132w	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
133s	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s, 106w
137w	Testing Econ. Minerals	1	4	Sr.E.M.(Geol.)	73f
140w	Applied Petrography	1	4	Sr.E.M.(Geol.)	111f, 113s
141s	Applied Petrography	1	4	Sr.E.M.(Geol.)	111f, 113s
144w	Construction and Interpretation of Geologic Maps	..	6	Jr.E.M.(Geol.)	73f
145s	Construction and Interpretation of Geologic Maps	..	12	Jr.E.M.(Geol.)	73f
150s	Field Geology	..	6 wks.	Jr.E.M.(Geol.)	125s
151f	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
152w	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
153s	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
166w	Mineralography	..	6	Sr.E.M.(Geol.)	111f
167s	Mineralography	..	6	Sr.E.M.(Geol.)	111f
246	Pre-Cambrian Geology	3	3	Elective	125s
247	Geol. and Exploration of Lake Superior Region	3	..	Elective	125s

1w,2s. General Geology. A synoptical treatment of materials of the earth, and of geologic processes. Physiographic, dynamic, structural, and historical geology. Mr. Thiel.

19s. Elements of Paleontology. An introduction to the study of fossil organisms. Lectures supplemented by field excursions. Mr. Stauffer.

23f,24w,25s. Elements of Mineralogy. The crystal systems; morphological, physical, chemical characters of minerals; occurrence, genesis, and uses of minerals; classifications and description of common minerals; rock minerals, and common rocks. Determinative work in the laboratory, blowpipe analysis, sight identification. Mr. Broderick, Mr. Gruner, Mr. Werner.

61f. Blowpipe Analysis. The determination of minerals by systematic blowpipe analysis. Mr. Broderick, Mr. Gruner.

65f. Crystallography. Projection and geometric relations of crystal planes; crystal nomenclature; the relation of special properties to morphology. A study of crystal models, crystal-drawing, identification of minerals from crystal measurements, and mathematical calculation. Mr. Broderick, Mr. Gruner.

73f. Economic Geology. Study of non-metallic minerals of economic value, and discussions of geologic guides to prospecting for these deposits. Mr. Schwartz.

80w. Advanced Historical Geology. The sequence of events in geologic history, of interest to the advanced student in mining. Mr. Stauffer, Mr. Thiel.

85s. Field Work. About two weeks in June are spent in geologic mapping of selected areas in the iron district of Minnesota. Involves preparation of geologic maps and written reports. Mr. Gruner, Mr. Schwartz.

91f-92w-93s. Paleontology. Index fossils of North America. A study of fossil forms with special reference to those of geologic importance; faunas and their correlation. Mr. Stauffer.

101f. Principles of Stratigraphy. Origin and structure of sedimentary deposits; the interpretation of these in relation to paleography; field work in connection with Cambrian and Ordovician problems. (Not offered in 1921-22.)

105f. Rock Study. The occurrence and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. Mr. Grout, Mr. Broderick, Mr. Thiel.

106w. Petrography. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and metamorphic rocks. The origin and classification of rocks. Mr. Grout, Mr. Broderick, Mr. Gruner, Mr. Thiel.

111f. Ore Deposits. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. Mr. Emmons.

112w. Geology of Petroleum. The nature, origin, and accumulation of petroleum; discussion of the various oil fields of the world. Mr. Emmons.

113s. Problems in Ore Deposits. Field excursions, map work, lectures on field and laboratory methods. Mr. Emmons.

124w,125s. Structural and Metamorphic Geology. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. Mr. Schwartz.

131f,132w,133s. Advanced Petrology. Advanced optical methods. Criteria for rapid identification of minerals and rocks. The uses of schedules and tables. Standard rock types. Regional and genetic studies. Petrographic reports. Mr. Grout.

137w. Testing Economic Minerals. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, clay, oil, building stone, and metallic ores. Mr. Grout.

140w,141s. Applied Petrography. Determination of ores and gangue minerals. Microscopic studies of paragenesis of ores and other mineral associations. Practical problems in mining and geology settled by microscopic and optical examinations. Mr. Grout.

144w,145s. Construction and Interpretation of Geologic Maps. Methods of geologic examination; problems in construction and interpretation of geologic maps and sections. Mr. Allison.

150s. Field Geology. Detailed, systematic work conforming with standards of official surveys. Preparation of geological maps, structure sections, reports; paragenesis of ores and their relations to geologic structures. Field for 1921, Black Hills, South Dakota. Reports to be written week before college opens in fall. Mr. Emmons, Mr. Schwartz.

151f,152w,153s. Advanced General Geology. Geologic processes and their results; development of the North American continent. Mr. Stauffer.

166w,167s. Mineralography. Methods of studying opaque minerals and the application of the methods to problems in ore genesis and history Mr. Broderick, Mr. Schwartz.

246. Pre-Cambrian Geology. The problems of pre-Cambrian correlation and structure; the pre-Cambrian stratigraphy of North America. (Given in alternate years.)

247. Geology and Exploration of Lake Superior Region. The geology of the Lake Superior iron districts. Methods used in the exploration of iron ore; interpretation of drill cores; cartographic expressions of drill data; models of drilled areas. Principles of magnetic surveying.

GERMAN

Professor Carl Schlenker; Assistant Professor James Davies; Instructor Cowden Laughlin.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
*4f, 5w, 6s	Beginning	3	Jr.E.M.(Geol.)	....
7f	Intermediate	3	Jr.E.M.(Geol.)	4-5-6 or equiv.
27f	Narrative Prose	4	Elective	2 yrs. prep.
*25w, 26s	Elementary Scientific	3	Elective	7
*28w, 29s	Advanced Chemical	3	Elective	27

* All quarters must be completed before credit is given in any one quarter.

4f-5w-6s. Beginning for Miners. Pronunciation, grammar, conversation; selected readings in easy prose. Mr. Schlenker, Mr. Davies.

7f. Intermediate for Miners. Continuation of Course 4-5-6. Mr. Davies.

27f. Narrative Prose. Reading, grammar review. Mr. Laughlin.

25w,26s. Elementary Scientific. Readings from simple expository German. Selections from works on chemistry. Mr. Davies.

28w,29s. Advanced Chemical German. Selections from more difficult works on chemistry. Mr. Laughlin.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Associate Professor Oscar E. Harder; Instructors Ralph L. Dowdell, Erwin H. Kersten, Elwyn L. Smith.

COURSES

No.	Title	Lec. hrs.	Lab. hrs.	Required of	Prerequisite courses
1w	Assaying	4	..	All fr.	Chem. 14f, Geol. 23f
2w	Assaying Lab.	..	8	All fr.	Chem. 14f, Geol. 23f
3f	General Metallurgy	3	..	All soph.	1w, 2w, Chem. 16s
4w	Metallurgy of Pig Iron	3	..	All soph.	3f
5s	Met. Wrought Iron and Steel	3	..	All soph.	4w
6f	Ore-Testing	2	..	Sr.E.M.&Met.E.	107s
7f	Ore-Testing Lab.	..	8	Sr.E.M.&Met.E.	107s
8w	Spec. Prob. in Ore-Test.	..	4	Sr.E.M.&Met.E.	107s
9s	Spec. Prob. in Ore-Test.	..	8	Sr.E.M.&Met.E.	107s
10w	Advanced Metallurgy	4	6	Sr.Met.E.	107s
11s	Advanced Metallurgy	4	6	Sr.Met.E.	107s
12f	Ore-Dressing	3	..	All jr.	Phys. 43s, Geol. 25s
13w	Ore-Dressing	3	..	All jr.	Met. 12f
14f	Ore-Dressing Lab.	..	4	Jr.Met.E.	Phys. 43s, Geol. 25s
15w	Ore-Dressing Lab.	..	4	Jr.Met.E.	Met. 12f, 14f
16s	Ore-Dressing Lab.	..	6	Jr.Met.E.	Met. 13w, 15w
17s	Ore-Dressing Lab.	..	6	Jr.E.M.&E.M.(Geol.)	Met. 13w
18f	Thesis in Metallurgy	..	8	Sr.Met.E.	Satisfactory completion of jr. year
19w	Thesis in Metallurgy	..	18	Sr.Met.E.	18f
20s	Thesis and Specifications	..	18	Sr.Met.E.	19w
21s	Field Work in Met.	..	**	Jr.Met.E.	Same as 18f
22f	Metallurgy	3	..	M.E.&Chem.Elective	Chem. 8s or equiv.
23w	Metallurgy	3	..	E.E.&Chem.Elective	Chem. 8s or equiv.
105f	Met. of Base Metals	4	..	Jr.E.M.&Met.E.	3f
106w	Met. of Base Metals	4	..	Jr.E.M.&Met.E.	105f
107s	Met. of Precious Metals.	4	..	Jr.E.M.&Met.E.	106w
108f	Electrometallurgy	3	..	Sr.Met.E.	107s
150w	Mphy. for Elec. Eng.	2	3	Elective	....
151s	Adv. Mphy. for Elec. Eng.	2	3	Elective	150w
153f	Mphy., Long Course	3	4	Jr.Met.E.	Chem.28w, Phys.43s

** Ten days.

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prerequisite courses
154w	Mphy., Long Course....	3	4	Jr.Met.E.	153f
155s	Mphy., Long Course....	3	4	Jr.Met.E.	154w
156w	Mphy. for Mech. Eng...	2	3	Elective	....
157s	Adv. Mphy. for Mech. Eng.	2	3	Elective	156w
159s	Dental Metallography...	2	..	Elective	Chem. 21-22
160f	Mphy. for Chemists.....	2	2	Elective	Chem. 20
161w	Adv. Mphy. for Chemists	2	2	Elective	160f
162s	Adv. Mphy. for Chemists	2	2	Elective	160f
163f	Adv. Metallography.....	To be ar.		Elective	151 155, 157 or equiv.
164w	Adv. Metallography	To be ar.		Elective	.....
165s	Adv. Metallography	To be ar.		Elective	.....
201f	Adv. Mphy. for Gr. Students...	To be ar.		Elective	.....
202w	Adv. Mphy. for Gr. Students...	To be ar.		Elective	.....
203s	Adv. Mphy. for Gr. Students...	To be ar.		Elective	.....

1w. ASSAYING. The determination of values of ores, metallurgical products by the fire method. Lectures and recitations. MR. APPLEBY, MR. CHRISTIANSON.

2w. ASSAY LABORATORY. Practical determination of gold, silver, lead, and tin by the fire method. MR. CHRISTIANSON, MR. PEASE, MR. KERSTEN, MR. SMITH.

3f. GENERAL METALLURGY. Combustion, fuels, refractory materials, furnaces and fluxes. Lectures and recitations. MR. CHRISTIANSON.

4w. METALLURGY OF PIG IRON. General principles of iron blast-furnace practice. Construction of furnace, handling of stock, and products, principles of regulation. Lectures and recitations. MR. CHRISTIANSON.

5s. METALLURGY OF WROUGHT IRON AND STEEL. General principles involved in the production of wrought iron and steel. Lectures and recitations. MR. CHRISTIANSON.

6f. ORE-TESTING. General principles involved in determining the best method of extraction, including amalgamation, concentration, cyanidation, roasting, etc. Lectures and recitations. MR. CHRISTIANSON.

7f. ORE-TESTING LABORATORY. Practical determination of extraction and distribution of values in mill and metallurgical products. Methods of calculation. MR. CHRISTIANSON and Assistants.

8w. SPECIAL PROBLEMS IN ORE-TESTING. Continuation of Course 7f. Practical determinations for regulating metallurgical operations. MR. PEASE.

9s. SPECIAL PROBLEMS IN ORE-TESTING. Continuation of Course 8w. MR. PEASE.

10w. Advanced Metallurgy. Pyrometry, calorimetry, and metallurgical calculations to determine heat balance and heat distribution. Lectures and laboratory work. Mr. Christianson.

11s. Advanced Metallurgy. Design of furnaces, conferences and laboratory work. Mr. Christianson.

12f. Ore-Dressing. Crushing, sizing, classification, and concentration of ores. Lectures and recitations. Mr. Smith.

13w. Ore-Dressing. Continuation of Course 12f. Mr. Smith.

14f. Ore-Dressing Laboratory. Practical examination of ores and the use of ore-dressing machinery. Mr. Smith.

15w. Ore-Dressing Laboratory. Practical problems in ore-dressing. Mr. Smith.

16s. Ore-Dressing Laboratory. Continuation of Course 15w. Mr. Smith.

17s. Ore-Dressing Laboratory. Short course in the laboratory use of ore-dressing machinery. Mr. Smith.

18f. Thesis in Metallurgy. Conferences to select suitable problem together with preliminary laboratory work on problem selected. Mr. Christianson, Mr. Pease.

19w. Thesis in Metallurgy. Continuation of Course 18f. Mr. Christianson, Mr. Pease.

20s. Thesis and Specifications. Completion of thesis including specifications covering installation of a plant. Mr. Christianson, Mr. Pease.

21s. Field Work in Metallurgy. Study of metallurgical operations at smelters and mills. Detail reports are required covering plants visited. Mr. Christianson, Mr. Pease.

22f. Metallurgy of Base Metals. Short course for mechanical engineers. Special consideration is given to the mechanical appliances. Lectures and recitations. Mr. Christianson, Mr. Pease.

23w. Metallurgy of Base Metals. Short course for electrical engineers. Special consideration is given to electrical appliances. Lectures and recitations. Mr. Christianson, Mr. Pease.

105f. Metallurgy of Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining. Lectures and recitations. Mr. Pease.

106w. Metallurgy of Base Metals. Continuation of Course 105f. Mr. Pease.

107s. Metallurgy of the Precious Metals. Principles involved and methods used in the extraction of gold, silver, and other precious metals. Lectures and recitations. Mr. Pease.

108f. Electrometallurgy. Application of electricity to production of heat for smelting ores and refining metals. Costs of fuel and electricity for heating, relative efficiencies of electric and fuel furnaces. Construction of high-temperature furnaces and commercial plants Mr. Christianson.

150w. Metallography for Electrical Engineers. Principles of metallography, including pyrometry, thermal analysis, constitution diagrams, microscopic and photomicrographic technic; study of typical alloys with special reference to electrical resistance, conductivity, magnets, etc. Laboratory work and demonstrations. Mr. Harder, Mr. Dowdell.

151s. Advanced Metallography for Electrical Engineers. Continuation of 150w. Study of iron and steel, alloy steels, metals and alloys used in electrical engineering practice. Special problems for outside reading and for research. Laboratory work. Mr. Harder, Mr. Dowdell.

153f,154w,155s. Metallography. (Long course for metallurgical engineers.) Theory of metallic alloys. Metallographic technic. Properties of metals and alloys. Metallography of iron and steel and commercial alloys. Technical metallography. Laboratory work. Mr. Harder, Mr. Dowdell.

156w. Metallography for Mechanical Engineers. Principles of metallography, including pyrometry, thermal analysis, constitution diagrams, microscopic and photomicrographic technic; metallography and heat treatment of iron and steel. Laboratory work. Mr. Harder, Mr. Dowdell.

157s. Advanced Metallography for Mechanical Engineers. Continuation of 156w. Metallography of alloy steels, tool steels, high-speed tool steels, and important non-ferrous alloys; metallography applied to engineering practice and specifications. Outside reading and special reports. Laboratory work. Mr. Harder, Mr. Dowdell.

159s. Dental Metallography. Study of the dental alloys from the standpoint of metallography. Lectures, recitations, and demonstrations, taking up the most important metals and alloys, with special reference to those used in dentistry. Mr. Harder, Mr. Dowdell.

160f. Metallography for Chemical Students. Metallography, including constitution diagrams, preparation and standardization of thermocouples, preparation and thermal analysis of alloys, their microscopic examination and making photomicrographs; typical alloy systems such as iron-carbon (steel and cast iron); some non-ferrous alloys. Laboratory work. Mr. Harder, Mr. Dowdell.

161w. Advanced Metallography for Chemical Students. Metallography and heat treatment of iron and steel, including alloy steels, commercial uses of various steels, and engineering specifications. Laboratory work. Mr. Harder, Mr. Dowdell.

162s. Advanced Metallography for Chemical Students. Metallography of the non-ferrous metals with a study of the constitution diagrams, properties, and uses of important commercial alloys. Laboratory work. Mr. Harder, Mr. Dowdell.

163f,164w,165s. Advanced Metallography. Technical and scientific research. The study of steel rails, automobile and locomotive parts, tool steels, etc. Special problems in metallography with outside reading. Seminar work on the recent advances in metallography. Mr. Harder.

201f,202w,203s. Advanced Metallography for Graduate Students. Intended primarily for research work. Mr. Harder.

MILITARY SCIENCE

Professor Girard Sturtevant, Colonel, Infantry, Chairman; Assistant Professors Ben W. Feild, Major, Infantry; Laurence T. Walker, Major, Coast Artillery Corps; Lee R. Watrous, Jr., Major, Coast Artillery Corps; Harry C. Ingles, Major, Signal Corps; Edward G. Sherburne, Major, Infantry; Edgar B. Moomau, 1st Lieutenant, Infantry; Hal M. Rose, 1st Lieutenant, Cavalry; Instructors Alfred Brandt, Master Sergeant, Infantry; Harry E. Strider, Master Sergeant, Signal Corps; Joseph Havlicek, Regimental Commissary Sergeant, Retired; Joseph Lees, 1st Sergeant, Retired; John McWilliams, 1st Sergeant, Retired; William R. Finke, 1st Sergeant, Coast Artillery Corps; William L. Hogan, 1st Sergeant, Coast Artillery Corps; Aubrey R. Dunkum, 1st Sergeant, Coast Artillery Corps; Kenna B. Caldwell, Sergeant, Coast Artillery Corps; Henry W. Brown, Sergeant, Coast Artillery Corps; Clarence G. Lange, Sergeant, Field Artillery; Edmund T. McCann, Sergeant, Infantry; Fred Lillie, Sergeant, Infantry; Prestice B. Rhodes, Sergeant, Infantry; Clarence C. Shelton, Sergeant, Infantry; Herman Smith, Sergeant, Infantry; Casper M. Heckemeyer, Sergeant, Infantry.

COURSES

No.	Title	Hrs.	Required of	Prereq. courses
1	First-year Basic Course R.O.T.C.....	3	†All fr.	None
2a	Second-year Basic Course R.O.T.C., Infantry	3	*Soph.	1
2b	Second-year Basic Course R.O.T.C., Coast Artillery	3	Soph.	1
2c	Second-year Basic Course R.O.T.C., Signal Corps	3	Soph.	1

* Work in military science and tactics for sophomores will open on Friday, September 16, at 8:30 a.m., and continue for ten days. Satisfactory completion of Course 2a, 2b, or 2c at that time is required of all sophomores. This course applies only to sophomores, who are required to leave the following May 1 for field work.

† Must be legally eligible for enrolment in Reserve Officers' Training Corps.

MINE PLANT AND MECHANICS

Professor Elting H. Comstock; Assistant Professors Anders J. Carlson, James C. Sanderson.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	Algebra and Solid Geometry	6	..	B fr.	..
2f	Algebra	6	..	A fr.	..
3s	Algebra	4	..	B fr.	1f
4w	Trigonometry	6	..	All fr.	..
5s	Analytical Geometry	6	..	All fr.	4w
6f	Calculus	4	..	All soph.	5s
7w	Calculus	3	..	All soph.	6f
8s	Calculus	6	..	All soph.	7w
9f	Mechanics	5	..	Jr.E.M.&Met.E.	8s
10w	Mechanics of Materials	5	..	Jr.E.M.&Met.E.	9f
11s	Mechanics of Materials	5	..	Jr.E.M.&Met.E.	10w
12f	Mine Plant	6	..	Jr.E.M.&Met.E.	8s
13w	Mine Plant	6	..	Jr.E.M.	12f
14s	Mine Plant	6	..	Jr.E.M.	13w
15w	Metallurgical Plant	3	..	Jr.Met.E.	12f
16s	Metallurgical Plant	3	..	Jr.Met.E.	15w
17f	Hydraulics and Water-Power	5	2	Sr.E.M.&Met.E.	11s
18f	Engineering Construction	..	8	Sr.E.M.	11s
19w	Mine-Plant Design	..	9	Sr.E.M.	18f
20s	Mine-Plant Design	..	12	Sr.E.M.	19w

1f. Algebra and Solid Geometry. Equations, involution and evolution, theory of exponents, surds, quadratic equation, theory of logarithms, determinants. Demonstrations of most important theorems of solid geometry. Volumes, approximate volumes, prismoidal formula, etc. Mr. Sanderson.

2f. Algebra. Functions, functional notation, factor and remainder theorems, factors and values of functions, development of functions, progressions, series, theory of equations, permutations and combinations, theory of logarithms, determinants. Mr. Comstock, Mr. Sanderson.

3s. Algebra. Continuation of 1f. Functions, functional notation, factor and remainder theorems, factors and values of functions, development of functions, progressions, series, theory of equations, permutations and combinations. Mr. Sanderson.

4w. Trigonometry. Trigonometric ratios, right triangles, definitions of trigonometric functions, analytic relations, trigonometric equations, etc., solution of spherical triangles. Mr. Comstock, Mr. Sanderson.

5s. Analytical Geometry. Systems of coördinates, loci, equations, properties of straight line, transformation of coördinates, equations and properties of conics, equations of second degree, higher plane curves, space coördinates, point, plane, quadric surfaces, etc., empirical equations, graphic algebra. Mr. Sanderson.

6f,7w,8s. CALCULUS. Differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, indeterminate forms, partial derivatives, change of variable, elementary integration, undetermined coefficients, rationalization, formulas of reduction, some differential equations of mechanics. MR. SANDERSON.

9f. MECHANICS. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work and energy. MR. CARLSON.

10w,11s. MECHANICS OF MATERIALS. Mechanical and elastic properties of materials of construction; beams, columns, shafts, hollow cylinders and spheres, rollers, plates; theory of internal stress; reinforced concrete. MR. CARLSON.

12f,13w,14s. MINE PLANT. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, rock drills, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. MR. COMSTOCK.

15w,16s. METALLURGICAL PLANT. Power, air, and water supply for metallurgical plants. MR. COMSTOCK.

17f. HYDRAULICS AND WATER-POWER. Laws of the equilibrium, pressure and flow of liquids, hydrographs and mass diagrams, estimate of power to be developed at a power site, design of dams and hydro-electric plants, theory of water wheels and turbines, speed control, power-house equipment, transmission. MR. CARLSON.

18f. ENGINEERING CONSTRUCTION. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures, design of mining structures. MR. CARLSON.

19w,20s. MINE-PLANT DESIGN. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. MR. COMSTOCK, MR. CARLSON.

MINING

Associate Professor WALTER H. PARKER; Instructor LOUIS S. HEILIG.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prerequisite courses
1s	Introductory Mining....	4	..	All soph.	..
2f	Exploration	5	..	Jr.E.M.&E.M.(Geol.)	1s
3w	Tunneling	5	..	Jr.E.M.&E.M.(Geol.)	2f
4s	Mining Methods.....	5	..	Jr.E.M.&E.M.(Geol.)	3w
5s	Practical Mining	..	2 wks.	Jr.E.M.&Met.E.	Satisfactory completion of junior yr.

No.	Title		Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
6f	First Aid	..	*		All jr.	..
51f	Mine Rescue	..	*		All sr.	..
52f	Mining Methods	5	..		Sr.E.M.&E.M.(Geol.)	4s
53w	Mine Management	5	..		Sr.E.M.&E.M.(Geol.)	52f
54s	Mine Administration	5	..		Sr.E.M.&Met.E.	53w
55f	Thesis	..	2		Sr.E.M.	4s
56w	Thesis	..	12		Sr.E.M.	55f
57s	Thesis	..	12		Sr.E.M.	56w

1s. Introductory Mining. Introductory mining course, preparatory to sophomore field trip. Mr. Heilig.

2f. Exploration. Occurrence of ore-bodies, prospecting, exploration, boring, explosives, drilling, and blasting. Mr. Heilig.

3w. Tunneling. Tunneling, drifting, shaft-sinking, raising, and mining methods. Mr. Parker.

4s. Mining Methods. Underground mining methods and support of underground excavations. Mr. Parker.

5s. Practical Mining. Study of mining operations. Mine plant and mining work in one or more mining camps. Mr. Parker, Mr. Comstock.

6f. First Aid. Course in first aid to the injured, given by the staff of the United States Bureau of Mines car.

51f. Mine Rescue. Course in mine rescue, given by the staff of the United States Bureau of Mines car.

52f. Mining Methods. Coal mining, open-pit work, quarrying, placer mining, hydraulic mining and dredging. Mr. Parker.

53w. Mine Management. Mine drainage, mine ventilation, mine transportation, mine sanitation, mine hygiene, cost accounting, and mine examination. Mr. Parker.

54s. Mine Administration. Course in mining law, mine management and economics of mining. Mr. Parker.

55f. Thesis. Preparatory work on the mining thesis. Mr. Parker, Mr. Heilig.

56w. Thesis. Preparation of an original thesis on some mining project, covering the exploration and development of a mining property. Mr. Parker.

57s. Thesis. Completion of thesis project. Mr. Parker.

* 15 hours a week.

MINING ENGINEERING

Associate Professor EDWIN M. LAMBERT.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	Mine-Surveying	3	..	All soph.	Math. 4w
2w	Mine-Surveying	3	..	All soph.	1f
3s	Mine-Surveying	3	4	All soph.	2w
4s	Field Work	..	7 wks.	All soph.	3s
5w	Mine-Mapping	..	6	All jr.	4s
6s	Mine-Mapping	..	6	Jr.E.M.&Met.E.	5w

1f-2w-3s. MINE-SURVEYING. Theory and problems in mine-surveying including land subdivision, stadia measurements, triangulation, railroad curves and cross-sections, computation of areas by coördinates; differential leveling, topographic map-reading, solar observations, shaft plumbing, underground traversing and leveling. MR. LAMBERT.

4s. FIELD WORK. Practice in general plane surveying during the month of May. Practice in underground surveying during the first three weeks of June. This work is given on the iron ranges of Minnesota. MR. LAMBERT, MR. CARLSON.

5w-6s. MINE-MAPPING. Mine-mapping in accordance with prevalent practice in mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. MR. CARLSON, MR. HEILIG.

PHYSICS

Professors HENRY A. ERIKSON, ANTHONY ZELENY; Professorial Lecturer LOUALLEN F. MILLER.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
3f	Elements of Mechanics	3	..	All soph.	Math. 5s
4f	Mechanics Laboratory	..	2	All soph.	With 3f
23w	Heat	3	..	All soph.	3f
24w	Heat Laboratory	..	2	All soph.	4f and with 23w
43s	Magnetism and Electricity	3	..	All soph.	3f
44s	Magnetism and Electricity Lab.	..	2	All soph.	4f and with 43s

3f. ELEMENTS OF MECHANICS AND SOUND. Mechanics of solids, fluids, wave motion, and sound. A study of the simpler fundamental principles. First part of a general Course 3, 23, 33, 43. Course 4 should be taken in conjunction with this course. MR. ERIKSON, MR. MILLER.

4f. ELEMENTS OF MECHANICS AND SOUND LABORATORY. Measurements in the mechanics of solids, fluids, wave motion, and sound; the laboratory part supplementing Course 3. One two-hour session in the laboratory a week. MR. ERIKSON, MR. MILLER.

23w. Heat. A study of the principles underlying heat phenomena. Course 24 should be taken in conjunction with this course. Mr. Miller.

24w. Heat Laboratory. The laboratory part supplementing Course 23. One two-hour session in the laboratory a week. Mr. Miller.

43s. Magnetism and Electricity. A study of the principles underlying magnetic and electric phenomena. Course 44 should be taken in conjunction with this course. Mr. Zeleny, Mr. Miller.

44s. Electrical Laboratory. The laboratory part supplementing Course 43. One two-hour session in the laboratory a week. Mr. Zeleny, Mr. Miller.

ROMANCE LANGUAGES

Professors Everett W. Olmsted, Irville C. LeCompte, Colbert Searles; Associate Professors Ralph House, Ruth S. Phelps.

COURSES

No.	Title	Rec. hrs	Required of	Prereq. courses
*1-2	Beginning French	5	Jr.E.M.(Geol.)	....
3-4	Intermediate French	5	Elective	1-2
*21-22-23	Survey French Lit.	3	Elective	3-4
*1-2	Beginning Spanish	5	Jr.E.M.(Geol.)	....
3-4	Intermediate Spanish	5	Elective	1-2
*65-66-67	Spanish Literature	3	Elective	3-4

1-2. Beginning French. Stress on accurate pronunciation, reading, reading vocabulary, and the essentials of grammar. Daily oral and written exercises (dictation and reproduction in French).

3-4. Intermediate French. French grammar, composition, and reading; increased use of French in the classroom. Selections from modern authors.

21-22-23. General Survey of French Literature. Lectures, recitations, and assigned readings. Designed to cover the whole period in historical outline. Selections from representative authors.

1-2. Beginning Spanish. Pronunciation, grammar, oral exercises, and translation.

3-4. Intermediate Spanish. Review of grammar, composition, conversation, and reading.

65-66-67. Spanish Literature. Discussions based upon texts and collateral reading.

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* All quarters must be completed before credit is given in any one quarter.
Note: Beginning and intermediate courses are offered every quarter.

The Bulletin of the University of Minnesota

The School of Mines Announcement for the Year 1922-1923

Vol. XXV No. 26 June 21 1922

Entered at the post-office in Minneapolis as second-class matter Minneapolis, Minnesota

Accepted for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized July 12, 1918

1922

JULY

Su	Mo	Tu	W	Th	Fr	Sa
..	..	..	..	..	..	1
2	3	**4**	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	**28**	29
30	31	..	..	..	..	..

AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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31	..	..	..	..	..	..

1923

JANUARY

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FEBRUARY

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MARCH

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APRIL

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MAY

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JUNE

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24	25	**26**	27	28	29	30
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JULY

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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UNIVERSITY CALENDAR

1922-23

1922			
September	15	Friday	Sophomores, School of Mines, report for military drill, 8:30 a.m.
September	16	Saturday	Payment of fees closes, except for new students
September	19	Tuesday	Juniors and seniors, School of Mines, report for completion of field work
September	22-26		Examinations for removal of conditions and entrance examinations; see below
			Physical examinations for all new students
September	25-26		Registration days
September	26	Tuesday	Payment of fees for new students closes
September	27	Wednesday	Fall quarter begins, 8:30 a.m.
October	14	Saturday	Class Scrap Day; classes dismissed the third and fourth hours
October	26	Thursday	Senate meeting, 4:30 p.m.
November	4	Saturday	Home Coming Day; classes dismissed the third and fourth hours
November	7	Tuesday	General Election Day; a holiday
November	11	Saturday	Armistice Day; a holiday
November	30	Thursday	Thanksgiving Day; a holiday
December	14	Thursday	Senate meeting, 4:30 p.m.
December	20	Wednesday	Fall quarter ends, Christmas vacation begins, 5:20 p.m.
1923			
January	4	Thursday	Christmas vacation ends, winter quarter begins, 8:30 a.m.
February	12	Monday	Lincoln's Birthday; a holiday
February	15	Thursday	Senate meeting, 4:30 p.m.
February	22	Thursday	Washington's Birthday; a holiday
March	23	Friday	Winter quarter ends, spring vacation begins, 5:20 p.m.
April	4	Wednesday	Spring vacation ends, spring quarter begins, 8:30 a.m.
May	1	Tuesday	Field work for sophomores and juniors in School of Mines begins
May	17	Thursday	Senate meeting, 4:30 p.m.
May	30	Wednesday	Memorial Day; a holiday
June	17	Sunday	Baccalaureate service
June	20	Wednesday	Fifty-first annual commencement
June	20	Wednesday	Spring quarter closes, 5:20 p.m.
June	23-25		Registration days for Summer Session
June	26	Tuesday	Summer Session and summer quarter begin
July	4	Wednesday	Independence Day; a holiday
August	3	Friday	Summer Session closes
September	7	Friday	Summer quarter closes

Program of Supplementary Examinations

Friday,	Sept. 22	9-12 a.m.	Physics
		2-5 p.m.	Chemistry, experimental engineering
Saturday,	Sept. 23	9-12 a.m.	Mathematics and mechanics
		2-5 p.m.	Drawing and descriptive geometry
Monday,	Sept. 25	9-12 a.m.	Metallurgical subjects
		2-5 p.m.	Electric power
Tuesday,	Sept. 26	9-12 a.m.	Geology and mineralogy
		2-5 p.m.	Mining subjects

THE SCHOOL OF MINES

FACULTY

Lotus Delta Coffman, Ph.D., President
William Watts Folwell, LL.D., President Emeritus
[1]Cyrus Northrop, LL.D., President Emeritus
William R. Appleby, M.A., Dean, and Professor of Metallurgy
Paul H. M.-P. Brinton, Ph.D., Professor of Analytical Chemistry
Thomas M. Broderick, Ph.D., Assistant Professor of Geology
Anders J. Carlson, C.E., Assistant Professor of Mine Plant and Mechanics
Peter Christianson, B.S., E.M., Professor of Metallurgy
Elting H. Comstock, M.S., Professor of Mine Plant and Mechanics
James Davies, Ph.D., Assistant Professor of German
William H. Emmons, Ph.D., Professor of Geology and Mineralogy
Henry A. Erikson, B.E.E., Ph.D., Professor of Physics
Leo J. Farrell, Captain Infantry, U.S.A., Assistant Professor of Military Science and Tactics
Isaac W. Geiger, Ph.D., Assistant Professor of Chemistry
Frank F. Grout, M.S., Ph.D., Professor of Geology and Mineralogy
Oscar E. Harder, Ph.D., Associate Professor of Metallography
William H. Kirchner, B.S., Professor of Drawing and Descriptive Geometry
Raymond E. Kirk, M.S., Assistant Professor of Chemistry
Samuel Kroesch, Ph.D., Assistant Professor of German
Edwin M. Lambert, M.E., Professor of Mining Engineering
Irville C. LeCompte, Ph.D., Professor of Romance Languages
Louallen F. Miller, B.S., Ph.D., Assistant Professor of Physics
Howard D. Myers, B.S. in C.E., Assistant Professor of Drawing and Descriptive Geometry
Everett W. Olmsted, Ph.D., Litt.D., Professor of Romance Languages
Walter G. Parker, E.M., Associate Professor of Mining
Levi B. Pease, M.S., Professor of Metallurgy
Ruth S. Phelps, M.A., Associate Professor of Romance Languages
Burton J. Robertson, E.E., Assistant Professor of Mechanical Engineering
Hal M. Rose, Captain, U.S.A., Assistant Professor of Military Science and Tactics
Frank B. Rowley, M.E., Professor of Mechanical Engineering
Henry H. Rutherford, B.A., Lieutenant Colonel, Medical Corps, U.S.A., Assistant Professor of Military Science and Tactics
William T. Ryan, E.E., Associate Professor of Electrical Engineering
James C. Sanderson, Ph.D., Assistant Professor of Mine Plant and Mechanics
Carl Schlenker, B.A., Professor of German
Colbert Searles, Ph.D., Professor of Romance Languages
George D. Shepardson, M.A., M.E., D.Sc., Professor of Electrical Engineering

[1] Died April 3, 1922.

EDWARD G. SHERBURNE, Major, U.S.A., Assistant Professor of Military Science and Tactics

CHARLES F. SHOOP, B.S., Associate Professor of Mechanical Engineering

CHARLES F. SIDENER, B.S., Professor of Chemistry

M. CANNON SNEED, Ph.D., Associate Professor of Chemistry

NEWTON W. SPEECE, Captain Infantry, U.S.A., Assistant Professor of Military Science and Tactics

CLINTON R. STAUFFER, B.S., Ph.D., Professor of Geology

GIRARD STURTEVANT, Colonel Infantry, U.S.A., Professor of Military Science and Tactics

RUSSELL C. THROCKMORTON, Captain Infantry, U.S.A., Assistant Professor of Military Science and Tactics

ANDREW C. TYCHSEN, Captain Infantry, U.S.A., Assistant Professor of Military Science and Tactics

LAURENCE T. WALKER, Major, U.S.A., Assistant Professor of Military Science and Tactics

JAMES E. WARE, Lieutenant Colonel, U.S.A., Retired, Assistant Professor of Military Science and Tactics

LEE R. WATROUS, JR., Major, U.S.A., Assistant Professor of Military Science and Tactics

JAMES D. WATSON, JR., Captain Signal Corps, U.S.A., Assistant Professor of Military Science and Tactics

FREDERICK R. WUNDERLICH, D.D.S., Major Dental Corps, U.S.A., Assistant Professor of Military Science and Tactics

ANTHONY ZELENY, M.S., Ph.D., Professor of Physics

IRA S. ALLISON, B.A., Instructor in Geology

CHARLES BOEHNLEIN, B.S., M.E., Instructor in Mathematics and Mechanics

EARL J. BLONSCHINE, Private First Class, D.E.M.L., Instructor in Military Science and Tactics

ALFRED BRANDT, Technical Sergeant, D.E.M.L., Instructor in Military Science and Tactics

HARRY W. BROWN, Sergeant, D.E.M.L., Instructor in Military Science and Tactics

HENRY DAHL, First Sergeant Retired, D.E.M.L., Instructor in Military Science and Tactics

RALPH L. DOWDELL, Met.E., Instructor in Metallography

AUBREY R. DUNKUM, Staff Sergeant, D.E.M.L., Instructor in Military Science and Tactics

JOHN W. GRUNER, B.A., M.S., Instructor in Geology

JOSEPH HAVLICEK, Regimental Commissary Sergeant, D.E.M.L., Instructor in Military Science and Tactics

LOUIS S. HEILIG, E.M., Instructor in Mining

CARL JENSEN, Regimental Supply Sergeant, U.S.A., Retired, Instructor in Military Science and Tactics

ERWIN H. KERSTEN, E.M., Instructor in Metallurgy

CLARENCE G. LANGE, Sergeant, D.E.M.L., Instructor in Military Science and Tactics

EDMUND T. MCCANN, Sergeant, D.E.M.L., Instructor in Military Science and Tactics
JOHN MCWILLIAMS, First Sergeant, D.E.M.L., Instructor in Military Science and Tactics
NORVILLE C. PERVIER, M.S., Instructor in Chemistry
ORRIN W. POTTER, E.M., Instructor in Drawing and Descriptive Geometry
CLAYTON M. REASONER, M.E., Instructor in Metallography
LANDON A. SARVER, M.A., Instructor in Chemistry
GEORGE M. SCHWARTZ, M.A., Instructor in Geology
ELWYN L. SMITH, B.S., Instructor in Metallurgy
HARRY E. STRIDER, Technical Sergeant, D.E.M.L., Instructor in Military Science and Tactics
GEORGE W. SWENSON, B.S. in E.E., Instructor in Electrical Engineering
GEORGE A. THIEL, M.A., Instructor in Geology
W. COURTNEY WERNER, B.A., Instructor in Geology
JOE WIER, Sergeant, D.E.M.L., Instructor in Military Science and Tactics
ELIZABETH B. HENDERSON, Librarian

GENERAL INFORMATION

The School of Mines was established by the Board of Regents in 1888, upon recommendation of the general faculty of the University. The buildings and laboratories of the school are located on the main campus of the University. The mining districts of Minnesota are within a few hours, by rail, of Minneapolis. The heartiest coöperation exists between the various mine managements and the school, so that the mining properties are at all times open to parties from the school for observation and study trips. Practical surveying, geological field work, and underground work are carried on in one or more of the districts. Students in the School of Mines have, therefore, all the advantages afforded by a large university combined with ample opportunity for field observation and experience.

The School of Mines occupies the new building provided by the Legislature of 1913. In the basement are the assay and electrometallurgical laboratories, together with machinery room, instrument room, balance room, furnace rooms, and necessary storerooms. On the first floor are the administrative offices, and offices and lecture rooms of the departments of Metallurgy and Mine Plant and Mechanics. On the second floor are the offices, lecture rooms, and drafting rooms of the Department of Mining, the ore-dressing laboratory, and the library of the school. On the third floor are the offices, laboratories, and lecture rooms of the Department of Metallography, Department of Mining Engineering, junior drafting room, darkrooms, blue printing room, and offices and computing rooms for the branch of the experiment station serving the tax commission.

DEGREES

In the School of Mines there are three regular courses of study, viz., Mining Engineering, Mining Engineering specializing in Geology, and Metallurgy, leading to the degree of engineer of mines (E.M.), engineer of mines in geology [E.M.(Geology)], and metallurgical engineer (Met.E.) respectively.

The degree of metallurgical engineer may be conferred upon a candidate who received the degree of engineer of mines in four years, and vice versa, provided such candidate completes an additional year's work at the school and presents a suitable thesis.

Students in the College of Science, Literature, and the Arts, in the College of Engineering and Architecture, and in the School of Chemistry, who contemplate taking a degree in this school after completing their course, are recommended to select their electives with reference to as full a preparation as possible for the technical work of the course they propose to enter.

CLASSIFICATION OF SUBJECTS

The work falls under the following subdivisions, supplemented by thoro courses in mechanics, mathematics, surveying, physics, chemistry, and the necessary theory and practice of structural, mechanical, and electrical engineering.

(a) *Geology*—to determine the location of the ore. (b) *Mineralogy*—to determine its nature. (c) *Assaying*—to determine whether or not it has value for treatment. (d) *Mining engineering*—to furnish material for treatment. (e) *Mine plant*—to provide the physical equipment for mining and treating the ore. (f) *Ore-testing*—to determine best methods of treatment. (g) *Ore-dressing*—to furnish products for metallurgical treatment. (h) *Metallurgy*—to smelt and refine ores and ore-dressing products; reduction to metals. (i) *Metallography*—to study metals and their alloys.

EXPERIMENT STATION

The School of Mines Experiment Station was established in 1911 and is maintained to promote the development of the mining and mineral resources of the state; to assay specimens of ores, rocks, clays, and minerals; to make such assays free of charge for private parties subject to such regulations as the Board of Regents may deem necessary; to make mining and metallurgical experiments in the treatment of such substances and in the utilization of mining and metallurgical by-products; to investigate methods of mining and the use of explosives; to undertake such other mining and metallurgical problems as may seem desirable; to make all ore estimates for the tax commission, and to do such other work along the lines above outlined as may be requested by other state departments. Coöperation has been effected with the United States Bureau of Mines, the United States Geological Survey, the Minnesota Geological Survey, and the School of Chemistry.

The experiment station is prepared to assist citizens interested in these lines of work, and to assay specimens of ore, rocks, clays, and minerals found within the state, free of charge.

In submitting samples the sender must state the exact location in which each sample was found, giving all possible additional information. This information, together with results of any test or analysis, will be on file and available to the public at the office of the station. Citizens desiring free assay privileges must agree to give accredited representatives of the School of Mines Experiment Station and of the Geological Survey access to the property should they desire to visit the same for purposes of examination and geological study.

Correspondence will receive prompt attention, but consultations generally prove more satisfactory.

Each sample should be numbered for identification and bear the name and address of the sender. All shipments must be delivered to the Minnesota School of Mines, charges prepaid. Shipping tags will be furnished upon request.

Address all communications to William R. Appleby, Director, Minnesota School of Mines Experiment Station, the University of Minnesota, Minneapolis, Minnesota.

ADMISSION

The courses leading to the degrees of engineer of mines, engineer of mines (in geology), and metallurgical engineer may be completed in four years.

Freshmen will be divided into two section as follows:

a. Those entering with credits in higher algebra and solid geometry.

b. Those entering without credits in higher algebra and solid geometry. Students in section b will carry a special course in mathematics during their freshman year.

Details as to admission and entrance requirements, description of subjects accepted for admission, and list of fees and expenses will be found in the bulletin of general information, which will be sent to any address upon application to the registrar, the University of Minnesota, Minneapolis.

UNCLASSED STUDENTS

No unclassed students will be admitted to the School of Mines.

ADMISSION TO ADVANCED STANDING

Students who desire to obtain advanced standing must present their applications and certificates to the departments concerned, obtain a written statement from the department, showing the exact credit allowed, and present this to the Enrolment Committee of the School of Mines.

FEES

Tuition fees (per quarter)	
Residents of Minnesota	$30.00
Non-residents	40.00
Deposit (first quarter only)	5.00
Military deposit (required of all students taking drill)	10.00
Minnesota Union (per quarter)	1.00
Post-office box (per quarter)	.20
Special fees	
Examination for removal of condition	1.00
Examinations for credit (after the first six weeks in residence)	5.00
Special examinations	5.00
Chemistry deposit	5.00

Penalty Fees

Registration penalties.—A penalty fee for late registration, late change of registration, or late payment of fees shall be two dollars ($2) and one dollar ($1) additional for each day of delay after classes begin, provided that no student shall pay more than twelve dollars ($12) of penalty in any quarter.

GRADUATION

Students completing courses of study to the satisfaction of the faculty are entitled to receive the appropriate degrees. Any person may undergo, at suitable times, examination in any subject. If such person pass in all the studies and exercises of a course, he is entitled to the appropriate degree, provided that at least the full year be spent at the University before such degree shall be granted, and provided the examination in every case be held before a committee of the faculty appointed for that purpose.

Seniors must be in regular attendance at all classes until after the final examination for the third quarter. Irregular attendance will debar a student from entering all final examinations.

THESIS

The thesis work is intended to bring in review and connect the work in mining and metallurgy, geology and mineralogy, mechanical and electrical engineering, mathematics, and mechanics.

It has been found that this purpose is most satisfactorily accomplished by assigning to each student a project, embracing the prospecting, development, and equipment of a group of mining claims, for candidates for the degree of engineer of mines; the investigation of a problem in mining geology, for candidates for the degree of engineer of mines (in geology); and the investigation of a metallurgical problem, for candidates for the degree of metallurgical engineer.

As much latitude as possible will be allowed the student in the choice of type of deposit and location. He must select a suitable project during the summer preceding the senior year. Outlines are furnished setting forth the lines of investigation necessary to obtain the required data. The junior field work affords ample opportunity therefor.

Prior to the reopening of field work at the School of Mines, Tuesday, September 19, 1922, each student is required to submit to the department concerned an outline embodying the principal features of the project, together with a topographic map and a sufficient number of photographs to represent clearly the locality. Unless this outline is submitted when due and is accepted by the department, final registration for the first semester, senior year, will not be permitted.

Students may, if they so desire, take a reasonable number of samples on which to make assays and hand laboratory tests during the ore-testing laboratory work given in the first semester, senior year.

All preliminary work must be done and final work on the project must be under way by December 1. On April 7 the text of the thesis must be completed and submitted for final approval. Completed work (typewritten and bound) together with all tracings and one set of clear blue prints therefrom must be in and accepted not later than April 27. Theses will not be accepted or examined after these dates. Unless the above conditions are complied with no student can expect to graduate with his class.

These theses shall become the property of the school.

SPECIAL NOTES

Students failing to receive a quarter mark of 75 per cent in any subject shall have the privilege of a supplementary examination before the opening of the following year.

Each student must obtain from the registrar his average in all subjects and present himself for supplementary examinations, according to the program on page 4.

Failure of the registrar to notify a student of deficiencies will not be accepted as a reason for neglecting to report for necessary supplementary examinations. Students failing to report for supplementary examinations will be compelled to take work over in class as in case of failures.

Students failing to pass supplementary examinations will become members of the succeeding class and must register for those subjects in which they have failed. They may take in addition other subjects not more than one year in advance of their class, with the exception of mining, mining engineering, and metallurgical courses, based upon requirements of the various courses and daily program. They may also take certain electives in other colleges provided suitable arrangements can be made.

Students failing to receive a quarter mark of 65 per cent in any subject shall not be allowed to pursue any dependent subject except by permission of the faculty. A student may be permitted to take the dependent subject conditionally for six weeks, at the end of which time he must have a passing grade in the subject if he is to continue it for the remainder of the quarter.

The faculty may exclude students from attending classes in any subject upon recommendation of the department concerned.

All students must report in time to make suitable arrangements with departments concerned in case of conflicts in program.

Students failing to present themselves for final examination for any quarter will be given zero on the examinations.

Students whose absences in any quarter exceed 20 per cent of the scheduled class hours will not be permitted to take examinations without special permission of the faculty.

Sophomores and juniors who, at the end of the winter quarter, are deficient in 15 hours or more of any subjects, or who, at the end of the spring quarter examination period for sophomores and juniors are deficient in any subject of the preceding year will not be eligible to take the spring field trip. Sophomores who are deficient in one or more quarters of surveying shall not be eligible for the sophomore field trip unless recommended for the trip by the Department of Mining Engineering and declared eligible by the faculty.

All subjects elected in other colleges become part of the School of Mines curriculum. All students are required to receive credits in these subjects before graduation.

During the academic year students will be held responsible for the receipt of official communications sent to them through the University post-office. During the summer vacation they will be held responsible for the receipt of such communications sent to the home address given on registration blank for the preceding academic year, unless formal notification of their correct address is filed with the registrar and the dean.

COURSES OF STUDY

UNIFORM CURRICULUM TO END OF SOPHOMORE YEAR

The courses leading to the degrees of engineer of mines, engineer of mines (in geology), and metallurgical engineer are uniform for the first two years.

Freshmen will be divided into two sections as follows:

a. Those entering with credits in advanced algebra and solid geometry.

b. Those entering without credits in advanced algebra and solid geometry.

Subjects with the prefix a are to be taken by freshman in section a; those with the prefix b are to be taken by freshmen in section b; and those without prefix are to be taken by students of both sections.

FRESHMAN YEAR

First Quarter

Chemistry 4f or 14f,* General Inorganic, 6 or 9†
Drawing 11f, Engineering Drawing, 10
a. Mathematics 2f, Algebra, 6
b. Mathematics 1f, Algebra and Solid Geometry, 6
Geology 23f, Elements of Mineralogy, 8
Military Science 1, Basic Course R.O.T.C., 3

Second Quarter

Chemistry 5w or 15w, General Inorganic, 6 or 9, Chem. 4f or 14f
Drawing 12w, Engineering Drawing, 8, Draw. 11f
Mathematics 4w, Trigonometry, 6
Metallurgy 1w, Assaying, 4, Chem. 4f or 14f, Geol. 23f
Metallurgy 2w, Assaying Laboratory, 8, Chem. 4f or 14f, Geol. 23f
Geology 24w, Elements of Mineralogy, 4, Geol. 23f
Military Science 1, Basic Course R.O.T.C., 3

Third Quarter

Chemistry 16s, Qualitative Analysis, 9, Chem. 5w or 15w
Drawing 13s, Engineering Drawing, 8, Draw. 12w
Mathematics 5s, Analytical Geometry, 6, Math. 4w
b. Mathematics 3s, Algebra, 4, Math. 1f
Geology 25s, Elements of Mineralogy, 8, Geol. 24w
Military Science 1, Basic Course R.O.T.C., 3

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* The suffixes f, w, or s, after the course number indicates the quarter in which a course is offered—fall, winter, or spring quarter respectively. Two or three suffixes indicate that a course is offered in each of the corresponding quarters.

† Figure following the descriptive name of a course indicates number of hours per week. Course names following indicate prerequisite courses.

SOPHOMORE YEAR

First Quarter

Drawing 14f, Descriptive Geometry, 3, Draw. 13s, Math. 5s
Geology 105f, Rock Study, 4, Geol. 25s
Mathematics 6f, Calculus, 4, Math. 5s
Metallurgy 3f, General, 3, Met. 1w, 2w, Chem. 16s
Mining Engineering 1f, Mine-Surveying, 3, Math. 4w
Physics 3f, Elements of Mechanics, 3, Math. 5s
Physics 4f, Mechanics Laboratory, 2, Math. 5s
Military Science 2a, 2b, or 2c, Basic Course R.O.T.C.

Work in military science and tactics for sophomores will open on Friday, Sept. 15 at 8:30 a.m., and continue for ten days. Satisfactory completion of Course 2a, 2b, or 2c, at that time is required of all sophomores. This course applies only to sophomores who are required to leave the following May 1 for field work.

Second Quarter

Chemistry 28w, Quantitative Analysis, 8, Chem. 16s
Drawing 15w, Drafting, 4, Draw. 14f
Geology 1w, General, 3, Geol. 105f
Geology 106w, Petrography, 4, Geol. 105f
Mathematics 7w, Calculus, 3, Math. 6f
Metallurgy 4w, Met. of Pig Iron, 3, Met. 3f
Mining Engineering 2w, Mine-Surveying, 3, Min. Eng. 1f
Physics 23w, Heat, 3, Phys. 3f
Physics 24w, Heat Laboratory, 2, Phys. 4f

Third Quarter

Geology 2s, General, 7, Geol. 105f
Mathematics 8s, Calculus, 6, Math. 7w
Metallurgy 5s, Wrought Iron and Steel, 3, Met. 4w
Mining 21s, Introductory Mining, 4
Mining Engineering 3s, Mine-Surveying, 7, Min. Eng. 2w
Physics 43s, Magnetism and Electricity, 3, Phys. 3f
Physics 44s, Magnetism and Elec. Lab., 2, Phys. 4f

Mining Engineering 4s, Field Work beginning about May 1, 7 weeks, Min. Eng. 3s.
Geology 85, Field Work beginning about June 20, 2 weeks, Geol. 2s
Underground Mining Work, beginning about July 5

JUNIOR AND SENIOR YEARS

COURSES LEADING TO THE DEGREE OF ENGINEER OF MINES

JUNIOR YEAR

First Quarter

Experimental Engineering, M.E. 84f, Elementary Lab., 4, with Mech. 12f
Geology 73f, Economic, 3, Geol. 2s, 105f
Mechanics 9f, Mechanics, 5, Math. 8s.

Mechanics 12f, Mine Plant, 6, Math. 8s
Metallurgy 105f, Base Metals, 4, Met. 3f
Metallurgy 12f, Ore-Dressing, 3, Phys. 43s, Geol. 25s
Mining 30f, First Aid, 1 week
Mining 31f, Exploration, 5, Mining 21s

Second Quarter

Experimental Engineering, M. & M. 144w, Materials-Testing Lab., 4, with Mech. 10w
Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mechanics 13w, Mine Plant, 6, Mech. 12f
Metallurgy 106w, Base Metals, 4, Met. 105f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f
Mining 32w, Tunneling, 5, Mining 31f
Mining Engineering 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Mechanics 11s, Mechanics of Materials, 5, Mech. 10w.
Mechanics 14s, Mine Plant, 6, Mech. 13w
Metallurgy 107s, Precious Metals, 4, Met. 106w
Metallurgy 17s, Ore-Dressing Lab., 6, Met. 13w
Mining 33s, Mining Methods, 5, Mining 32w
Mining Engineering 6s, Mine-Mapping, 6, Min. Eng. 5w
Metallurgy 21s, Field Work in Metallurgy beginning about May 1, 10 days, satisfactory completion of junior year
Mining 34s, Field Work in Mine Plant and Mining beginning about May 1, 2 weeks, satisfactory completion of junior year

SENIOR YEAR

First Quarter

Electrical Engineering 41f, Electric Power, 5, Phys. 43s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Mechanics 17f, Water Power, 7, Mech. 11s
Mechanics 18f, Engineering Construction, 8, Mech. 11s
Metallurgy 6f, Ore-Testing, 2, Met. 107s
Metallurgy 7f, Ore-Testing Lab., 8, Met. 107s
Mining 41f, Mining Methods, 5, Mining 33s
Mining 40f, Mine Rescue, 1 week
Mining 44f, Thesis, 2, Mining 33s

Second Quarter

Experimental Engnieering, M.E., 181w, Advanced Lab., 4, Exp. Eng. M.E. 84f
Geology 112w, Petroleum, 3, Geol. 111f
Geology 80w, Advanced Historical, 3, Geol. 73f
Mech. 19w, Mine Plant Design, 9, Mech. 18f
Metallurgy 8w, Special Problems, 4, Met. 107s
Mining 42w, Mine Management, 5, Mining 41f
Mining 45w, Thesis, 12, Mining 44f

Third Quarter

Geology 113s, Problems in Ore Deposits, 4, Geol. 112w
Mechanics 20s, Mine Plant Design, 12, Mech. 19w
Metallurgy 9s, Special Problems, 8, Met. 107s
Mining 43s, Mine Administration, 5, Mining 42w
Mining 46s, Thesis 12, Mining 45w

DEPARTMENT OF MINING

The department is well supplied with samples of the smaller mine equipment, models, drawings, photographs, lantern slides, and mine maps. The lectures treat of prospecting, development, support of excavations, mining methods, mine administration, mining law, and the necessary allied subjects. The courses in mining extend through the sophomore, junior, and senior years.

FIELD WORK IN MINING

JUNIOR YEAR

At the end of the junior year students are required to study mine plant and mining methods in one or more mining districts under the direction of members of the faculty. This work begins about May 1, and not over three weeks will be devoted to it. The work is carried on in the leading western metal-mining districts, the exact location to be announced in April of each year. The expenses for the trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover board and lodging and necessary side trips. Any balance will be returned at the close of the work in the field.

All notes, data, and sketches necessary for a complete report on the field work, must be fully and neatly recorded in notebooks. These notebooks will be collected at the close of the trip and returned to the student at the reopening of field work at the school. In judging the character of the student's field work, equal importance will be attached to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below the standard that should be demanded of candidates for senior work. During the months of June, July, and August, the student is urged to spend at least six weeks in actual underground mining work in the West for which he may receive wages. The department will render all possible assistance in locating students in districts of their choice.

Field work will reopen at the School of Mines, Tuesday, September 19, 1922. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in mining and metallurgy must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: metallurgy, September 19 to 26, inclusive; mining and mine plant, September 27 to October 10, inclusive.

On October 10 all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings, to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 10. These reports shall become the property of the school.

The completion of sophomore and junior field work is a requisite for graduation, and satisfactory evidence thereof must be submitted to the department. Should a student, for sufficient reason, fail to complete this work in regular course, he may, with the consent of the department, be permitted to pursue his regular studies. In all such cases, however, the degree will be withheld until all field work is completed.

DEPARTMENT OF MINING ENGINEERING

MINE-SURVEYING

The work in surveying is given in the sophomore year and is designed primarily for mining engineers. The work begins with the elements of plane surveying, with special reference to the computations necessary, followed by the higher theoretical work in plane surveying and its application to the problems met in underground surveying. Beginning about May 1, the class devotes seven weeks to field work at some convenient point on the Mesabi, Cuyuna, or Vermilion Range. The exact location will be announced in March of each year. The expenses for this trip are estimated at $150.

The students will be divided into squads of two to four. Each student will be required to complete satisfactorily a practical course in plane and underground surveying including exercises in chaining and taping; adjustment and use of surveying instruments; solar and stellar observations; laying out railroad tangents and curves; making earthwork estimates; and other problems. In addition each squad will be required to make a yardage estimate of the stripping of an open-pit mine; to transfer a meridian, from the surface, underground and make a complete survey of an underground mine.

The data obtained will be used in the course in mine-mapping during the winter quarter of the junior year.

A full equipment of surveying instruments of the latest and best types is furnished each squad for this work.

Courses Leading to the Degree of Engineer of Mines in Geology

JUNIOR YEAR

First Quarter

Geology 61f or 65f, Blowpipe Analysis or Crystallography, 6, Geol. 25s
Geology 73f, Economic, 3, Geol. 2s, 105f
Geology 131f, Advanced Petrology, 6, Geol. 2s, 106w
Geology 151f, Advanced General, 3, Geol. 73f

German 24f or 27f, or French 1f or 21f, or Spanish 1f or 65f, 5 or 3
Mechanics 9f, Mechanics, 5, Math. 8s
Mining 30f, First Aid, 1 week
Mining 31f, Exploration, 5, Min. 21s

Second Quarter

Geology 124w, Struct. and Metamorphic, 3, Geol. 73f, 105f
Geology 132w, Advanced Petrology, 6, Geol. 2s, 106w
Geology 144w, Geologic Maps, 6, Geol. 73f
Geology 152w, Advanced General, 3, Geol. 73f
German 25w or 28w, or French 2w or 22w, or Spanish 2w or 66w, 5 or 3
Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mining 32w, Tunneling, 5, Min. 31f
Mining Engineering 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Geology 125s, Struct. and Metamorphic, 6, Geol. 73f, 105f
Geology 133s, Advanced Petrology, 6, Geol. 2s, 106w
Geology 145s, Geologic Maps, 12, Geol. 73f
Geology 153s, Advanced General, 3, Geol. 73f
Mechanics 11s, Mechanics of Materials, 5, Mech. 10w
Mining 33s, Mining Methods, 5, Min. 32w
Geology 150s, Field Work in Geology beginning about May 1, six weeks, Geol. 125s
Geologic Field Work beginning about June 15 with geologic surveys or private companies

SENIOR YEAR

First Quarter

Geology 91f, Paleontology, 3, Geol. 2s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w
Metallurgy 12f, Ore-Dressing, 3, Phys. 5s, Geol. 25s
Mining 40f, Mine Rescue, 1 week
Mining 41f, Mining Methods, 5, Min. 33s
Thesis, 8
Electives, 6

Second Quarter

Geology 92w, Paleontology, 3, Geol. 2s
Geology 112w, Petroleum, 3, Geol. 111f
Geology 137w, Testing Economic Materials, 5, Geol. 73f
Geology 140w, Applied Petrography, 5, Geol. 111f, 13s
Geology 166w, Mineralography, 6, Geol. 111f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f
Mining 42w, Mine Management, 5, Min. 41f

Third Quarter

Geology 93s, Paleontology, 3, Geol. 2s
Geology 113s, Problems in Ore Deposits, 4, Geol. 112w
Geology 141s, Applied Petrography, 5, Geol. 111f, 13s
Geology 167s, Mineralography, 6, Geol. 111f
Metallurgy 17s, Ore-Dressing Lab., 6, Met. 13w
Thesis, 10

FIELD WORK IN GEOLOGY

At the end of the sophomore year mining students are required to devote about three weeks to geologic mapping. This course usually comes after a seven-week course in surveying and the fields chosen are the Vermilion and Mesabi iron ranges of Minnesota. This work is intended to train the students in the interpretation of field relations and the preparation of geologic maps and cross sections.

The second field course in geology is required only of those students who are candidates for the engineer of mines (in geology) degree. The course begins early in May and is completed in June. The course requires altogether about six weeks' work, and the field chosen is the Black Hills region of South Dakota or some other western region. The expenses of the trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover lodging and necessary side trips. Any balance will be returned at the close of the work in the field. The student is trained in the interpretation of field data; in detailed mapping, underground and on the surface; in the preparation of geologic cross sections through mines; and he may gather material which will serve as a basis for future study in advanced courses the following year. The work conforms to the standards of official surveys as nearly as practicable. In preparation for the trip a lecture of one hour per week will be scheduled for part of the third quarter preceding the trip. At the close of the field season the students are expected to obtain positions with mining companies either as miners or as engineers, or if openings are available, they may enter geological surveys for the season's work.

Field work in geology for students having taken either of the above trips will reopen at the School of Mines, Tuesday, September 19, 1922. The final reports covering the field work must be prepared at the School of Mines under the direct supervision of the Department of Geology. These reports are to be turned in to the department on September 26.

Courses Leading to the Degree of Metallurgical Engineer

JUNIOR YEAR

First Quarter

Geology 73f, Economic, 3, Geol. 2s, 105f
Mechanics 9f, Mechanics, 5, Math. 8s
Mechanics 12f, Mine Plant, 6, Math. 8s
Metallurgy 12f, Ore-Dressing, 3, Phys. 43s, Geol. 25s
Metallurgy 14f, Ore-Dressing Lab., 4, Phys. 43s, Geol. 25s

Metallurgy 105f, Base Metals, 4, Met. 3f
Metallurgy 153f, Metallography, 7, Chem. 28w, Phys. 43s
Mining 30f, First Aid, 1 week

Second Quarter

Mechanics 10w, Mechanics of Materials, 5, Mech. 9f
Mechanics 15w, Metallurgical Plant, 3, Mech. 12f
Metallurgy 13w, Ore-Dressing, 3, Met. 12f, 14f
Metallurgy 15w, Ore-Dressing Lab., 4, Met. 12f, 14f
Metallurgy 106w, Base Metals, 4, Met. 105f
Metallurgy 154w, Metallography, 7, Met. 153f
Mining Engineering 5w, Mine-Mapping, 6, Min. Eng. 4s

Third Quarter

Mechanics 11s, Mechanics of Materials, 5, Mech. 10w
Mechanics 16s, Metallurgical Plant, 3, Mech. 15w
Metallurgy 16s, Ore-Dressing Lab., 6, Met. 13w, 15w
Metallurgy 107s, Precious Metals, 4, Met. 106w
Metallurgy 155s, Metallography, 7, Met. 154w
Mining Engineering 6s, Mine-Mapping, 6, Min. Eng. 5w
Metallurgy 21s, Field Work in Metallurgy beginning about May 1, 10 days, satisfactory completion of junior year
Mining 34s, Field Work in Mine Plant and Mining beginning about May 1, 2 weeks, satisfactory completion of junior year

SENIOR YEAR

First Quarter

Electrical Engineering 41f, Electric Power, 5, Phys. 43s
Geology 111f, Ore Deposits, 3, Geol. 73f, 106w, or
Mechanics 18f, Engineering Construction, 8, Mech. 11s
Mechanics 17f, Water Power, 7, 11f
Metallurgy 6f, Ore-Testing, 2, Met. 107s
Metallurgy 7f, Ore-Testing Lab., 8, Met. 107s
Metallurgy 108f, Electrometallurgy, 3, Met. 107s
Metallurgy 18f, Thesis, 8
Mining 40f, Mine Rescue, 1 week

Second Quarter

Geology 112w, Petroleum, 3, Geol. 111f, or
Mechanics 19w, Mine Plant Design, 9, Mech. 18f
Metallurgy 8w, Special Problems in Ore-Testing, 4, Met. 107s
Metallurgy 10w, Advanced Metallurgy, 10, Met. 107s
Metallurgy 19w, Thesis, 18, Met. 18f
Metallurgy 164w, Advanced Metallography, 3, Met. 155s, or
Geology 80w, Advanced Historical, 3, Geol. 73f, or
Mining 42w, Mine Management, 5, Min. 41f.

Third Quarter

Metallurgy 9s, Special Problems in Ore-Testing, 8, Met. 107s
Metallurgy 11s, Advanced Metallurgy, 10, Met. 107s
Metallurgy 20s, Thesis, 18, Met. 19w
Metallurgy 165s, Advanced Metallography, 3, Met. 155s, or
Geology 113s, Problems in Ore Deposits, 4, Geol. 112w, or
Mining 43s, Mine Administration, 5, Min. 42w

DEPARTMENT OF METALLURGY

This department is well supplied with representative ores of all the most important metals, drawings of furnaces, models and samples of all the different furnace products. The lectures treat of all the principal methods now in use. The practical work consists in visits to smelting and refining works which are accessible. The work in metallurgy extends through three years.

ASSAYING

The lectures treat of, and describe, apparatus, reagents, assay furnaces, fuels, etc., in connection with this subject. The principles of assaying and sampling are fully explained. A collection of representative ores of various metals with a collection of corresponding slags is shown, and instruction is given as to nature and quality of fluxes. Special and rapid methods of testing slags and metallurgical products as employed in western smelting works are emphasized.

The laboratory course includes preparing and testing reagents, making cupels, etc., and assaying samples of ores, furnace and mill products, and bullion; different charges are tried and practical conclusions drawn.

Great importance is attached to the work in the laboratory. A large, well-ventilated furnace room in which are located muffle and crucible furnaces, and another room of similar dimensions equipped with desks, pulp and bead balances, afford accommodations to a large number of students. Ores of various metals of known value are given the students who are required to make up the necessary charges and submit their report in detail. This work is offered to students completing the necessary courses in mineralogy and chemistry.

ORE-DRESSING

The lectures and recitations in ore-dressing extend through the junior year, and comprise a detail study of ore-dressing and concentrating machinery, together with a study of typical combinations of dressing machines as found in the various mining districts of the United States. In connection with the theoretical work, the ore-dressing laboratory and testing plant of the school are utilized for illustration, and practical use of ore-dressing machinery.

ORE-TESTING

The lectures treat of the problems in ore-testing such as extraction and losses in roasting, concentration, and other milling operations. Both the ore-dressing laboratory and the Mines Experiment Station laboratory

are available for working out practical problems. The Mines Experiment Station laboratory is maintained to aid the mining interests of the state of Minnesota in solving problems connected with concentration and conservation of the iron and manganiferous ores of the state.

The School of Mines laboratories therefore serve both educational and commercial needs.

Educational.—The student becomes familiar with the use of the various types of machines such as crushers, rolls, classifiers, concentration and flotation machinery.

Commercial.—The laboratories are used by the Mines Experiment Station to determine the best methods of treatment to produce a commercial product at the lowest cost. Recently additional commercial machinery has been obtained and new appliances are constantly being developed. Commercial samples varying from 500 pounds to carload lots can be treated by various methods.

FIELD WORK IN METALLURGY

At the end of the junior year students are required to study practical operations at one or more smelters and mills. This begins about May 1. The expenses for this trip are estimated at $225. A deposit of $50 must be made before starting on the trip to cover board and lodging and necessary side trips. Any balance will be returned at the close of the work in the field.

All notes, data, and sketches, necessary for a complete report on the field work, must be fully and neatly recorded in notebooks. These notebooks will be collected at the end of the trip and returned to the student at the reopening of field work at the school. In judging the character of the student's field work equal importance will be given to the completed report and to the original field notes. The department reserves the right to reject notebooks considered below standard.

Upon termination of the junior field work in metallurgy and two weeks in mining and mine plant (not later than June 1), the members of the junior class who are candidates for the degree of metallurgical engineer are urged to spend at least six weeks in practical work in one or more of the smelters or mills, for which they may receive wages. The department will render all possible assistance in locating students in districts of their choice.

Field work will reopen at the School of Mines, Tuesday, September 19, 1922. No senior will be registered after that date. Registration will cover field work, electric power, and geology.

The final reports covering field work in metallurgy and mining must be prepared at the School of Mines under the direct supervision of the departments concerned. The program covering this work is as follows: metallurgy, September 19 to 26, inclusive; mining and mine plant, September 27 to October 10, inclusive.

On October 10, all seniors who expect to graduate must register for the remaining subjects. Prior to this date the student must submit a typewritten report on field work fully illustrated with drawings to scale, made from the field sketches, covering metallurgical and milling operations, and details of plant and equipment. Final registration will not be allowed until after reports on field work are accepted. All final reports, therefore, must be presented on or before October 10. These reports shall become the property of the school.

METALLOGRAPHY

Courses in metallography are offered to candidates for the degree of metallurgical engineer in the School of Mines, to students in the colleges of Dentistry, Engineering and Architecture, Science, Literature, and the Arts, in the School of Chemistry, and in the Graduate School.

These courses deal with the study of metals and alloys. The lectures treat of, and describe, the apparatus used in connection with this subject, the method of preparing specimens, physical and metallographic principles involved, and the interpretation of the results of microscopic examination and thermal analysis. There is an elaborate file of references and abstracts relating to the whole field of metallography, furnishing up-to-date information on the various phases of the work. A collection of specimens, photomicrographs, and lantern slides covering wrought iron, low carbon structural, rail, and tool steels, brasses, bronzes, and other industrial alloys is available for study and comparison. The laboratory course includes the microscopic and pyrometric study of metals and alloys. The laboratories are equipped with grinding and polishing apparatus, microscopes, photomicrographic apparatus, vacuum electric furnace, carbon resistance furnaces, nichrome and platinum resistance furnaces of various designs, gas furnaces, heat-treating furnace, and pyrometers of the latest and improved types. There is a special darkroom for the preparation of photomicrographs.

DEPARTMENTAL STATEMENTS

EXPLANATION OF COURSE NUMBERS

The suffixes f, w, or s, indicate the quarter in which a course is offered, e.g., fall, winter, or spring quarters respectively. More than one suffix indicates that a course is offered in each of the corresponding quarters. No suffix indicates that the time of taking a course is to be arranged with the departments concerned.

All undergraduate courses are numbered from 1 to 100. All courses open to undergraduates and graduates are numbered from 101 to 200. Strictly graduate courses are numbered from 201 up.

CHEMISTRY

Professors Paul H. M.-P. Brinton, Charles F. Sidener; Associate Professor M. Cannon Sneed; Assistant Professors Isaac W. Geiger, Raymond E. Kirk; Instructors Norville C. Pervier, Landon A. Sarver.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
4f	General Inorganic Chemistry.....	3	3	All fr.	H.S.Chem.
5w	General Inorganic Chemistry.....	3	3	All fr.	4f
14f	General Inorganic Chemistry.....	3	6	All fr.	....
15w	General Inorganic Chemistry.....	3	6	All fr.	14f
16s	Qualitative Chemical Analysis....	3	6	All fr.	5w or 15w
28w	Quantitative Chemical Analysis...	1	7	All soph.	16s
123f	Adv. Analytical Chemistry.....	1	7	Elective	28w
124w	Adv. Analytical Chemistry.....	1	7	Elective	28w

4f. General Inorganic Chemistry. A study of the general laws of chemistry and of the non-metals, the metals, and their compounds. Mr. Kirk.

5w. General Inorganic Chemistry. A continuation of Course 4f. Mr. Kirk.

14f. General Inorganic Chemistry. A study of the general laws of chemistry and of the non-metals, the metals, and their compounds. Mr. Pervier.

15w. General Inorganic Chemistry. A continuation of Course 14f. Mr. Pervier.

16s. Qualitative Analysis. Laboratory work in systematic qualitative analysis with lectures on solutions, ionization, chemical and physical equilibrium, oxidation and reduction, etc. Mr. Kirk, Mr. Pervier.

28w. Quantitative Analysis. A short introductory course covering the general principles and methods of quantitative analysis, both gravimetric

and volumetric. Typical problems are assigned and attention given to proper laboratory practice. Mr. Brinton, Mr. Sidener, Mr. Sarver.

123f. Advanced Analytical Chemistry. Analytical methods for the determination of the common constituents of iron ore, iron, and steel are discussed and compared, with emphasis upon the general principles involved. Typical problems are assigned for laboratory practice. Mr. Sidener, Mr. Geiger, Mr. Sarver.

124w. Advanced Analytical Chemistry. A survey of the methods of analytical chemistry applied to the analysis of minerals and ores. Typical procedures for laboratory practice serve as a basis for discussion of more general methods. Mr. Brinton, Mr. Sidener, Mr. Geiger, Mr. Sarver.

DRAWING AND DESCRIPTIVE GEOMETRY

Professor William H. Kirchner; Assistant Professor Howard D. Myers; Instructor Orrin W. Potter.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
11f	Engineering Drawing	..	10	All fr.	....
12w	Engineering Drawing	..	8	All fr.	11f
13s	Engineering Drawing	..	8	All fr.	12w
14f	Descriptive Geometry	3	..	All soph.	13s, Math. 5s
15w	Drafting	..	4	All soph.	14f

11f. Engineering Drawing. Sketching, lettering, representation, elements of drafting, details of machines and structures, interpretation of working drawings. Mr. Kirchner, Mr. Potter.

12w. Engineering Drawing. Continuation of Course 11f. The elements of general drafting, mechanical drawing as a language. Lines, views, dimensions, standards, signs, abbreviations, and explanatory notes. Mr. Kirchner, Mr. Potter.

13s. Engineering Drawing. Continuation of Course 12w. The elements of general drafting. Maps and sketches. Brush and pen conventions. Mr. Kirchner, Mr. Potter.

14f. Descriptive Geometry. Projection; central and special cases, principles and application, representation of lines, planes, and solids, and of their relations; tangencies, intersections, and developments. Recitations, lectures, and solution of problems. Mr. Myers.

15w. Drafting. Graphics, machine drafting, and structural drafting. Instruction in drafting room methods. Mr. Myers.

ELECTRICAL ENGINEERING

Professor GEORGE D. SHEPARDSON; Associate Professor WILLIAM T. RYAN; Instructor GEORGE W. SWENSON.

COURSE

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. course
41f	Electric Power	2	3	Sr.E.M.	Physics 43s

41f. ELECTRIC POWER. Elementary principles of continuous currents. Continuous current generators and motors. Elementary principles of alternating currents. Alternating current generators, transformers, and motors. Measurement of power. Elementary principles of transmission and distribution. Lectures, recitation, laboratory work. MR. RYAN.

EXPERIMENTAL ENGINEERING

Professor FRANK B. ROWLEY; Associate Professor CHARLES F. SHOOP; Assistant Professor BURTON J. ROBERTSON; Instructor CHARLES BOEHNLEIN.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
M.E. 84f	Elementary Laboratory (General)	..	4	Jr. E.M.	With Mech. 12f
M.&M. 144w	Materials-Testing Laboratory	..	4	Jr. E.M.	With Mech. 10w
M.E. 181w	Advanced Laboratory (General)	..	4	Sr. E.M.	M.E. 84f

M.E.84f. ELEMENTARY GENERAL LABORATORY. Calibration of thermometers, gages, weirs, nozzle orifices, and meters. Efficiency of machines, friction of belting, friction tests; burning point, chill point, viscosity and specific gravity of oils. Tests of water motor, rams, and pulsometers. MR. SHOOP.

M.&M.144w. MATERIALS-TESTING LABORATORY. Investigation of physical properties of metals and engineering materials: wood, cement, ropes, etc., supplemented by lectures and materials of construction and methods of testing. Mining and metallurgical engineers. MR. BOEHNLEIN.

M.E.181w. ADVANCED GENERAL LABORATORY. Indicator practice, valve-setting, separating and throttling calorimeters, tests of steam engines, gas engines, pumps, air compressors, blowers, turbines, boilers, and power plant. MR. ROWLEY, MR. SHOOP.

GEOLOGY AND MINERALOGY

Professors WILLIAM H. EMMONS, FRANK F. GROUT, CLINTON R. STAUFFER; Assistant Professor THOMAS M. BRODERICK; Instructors IRA S. ALLISON, JOHN W. GRUNER, GEORGE M. SCHWARTZ, GEORGE A. THIEL, W. COURTNEY WERNER.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1w	General Geology	3	..	All soph.	105f
2s	General Geology	3	4	All soph.	105f
19s	Elem. of Paleontology	3	..	Elective	....
23f	Elem. of Mineralogy	4	4	All fr.	....
24w	Elem. of Mineralogy	2	2	All fr.	23f
25s	Elem. of Mineralogy	4	4	All fr.	24w
61f	Blowpipe Analysis	2	4	Elective	25s
65f	Crystallography	2	4	Elective	25s
73f	Econ. Geology	3	..	All jr.	2s, 105f
80w	Advanced Hist. Geology	3	..	Sr.E.M.&Met.E.	73f
85s	Summer Field Work	..	2 wks.	All soph.	2s
91f	Paleontology	3	..	Sr.E.M.(Geol.)	2s
92w	Paleontology	3	..	Sr.E.M.(Geol.)	2s
93s	Paleontology	3	..	Sr.E.M.(Geol.)	2s
101f	Principles of Stratigraphy	3	..	Elective	25s
105f	Rock Study	..	4	All soph.	25s
106w	Petrography	..	4	All soph.	105f
111f	Ore Deposits	3	..	All sr.	73f, 106w
112w	Geology of Petroleum	3	..	All sr.	111f
113s	Problems in Ore Deposits	..	4	All sr.	112w
124w	Struct. & Metamorph. Geol	3	..	Jr.E.M.(Geol.)	73f, 105f
125s	Struct. & Metamorph. Geol	6	..	Jr.E.M.(Geol.)	73f, 105f
131f	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s,106w
132w	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s,106w
133s	Advanced Petrology	3	3	Jr.E.M.(Geol.)	2s 106w
137w	Testing Econ. Minerals	1	4	Sr.E.M.(Geol.)	73f
140w	Applied Petrography	1	4	Sr.E.M.(Geol.)	111f, 113s
141s	Applied Petrography	1	4	Sr.E.M.(Geol.)	111f, 113s
144w	Construction and Interpretation of Geologic Maps	..	6	Jr.E.M.(Geol.)	73f
145s	Construction and Interpretation of Geologic Maps	..	12	Jr.E.M.(Geol.)	73f
150s	Field Geology	..	6 wks.	Jr.E.M.(Geol.)	125s
151f	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
152w	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
153s	Advanced General Geology	3	..	Jr.E.M.(Geol.)	73f
166w	Mineralography	..	6	Sr.E.M.(Geol.)	111f
167s	Mineralography	..	6	Sr.E.M.(Geol.)	111f
246	Pre-Cambrian Geology	3	3	Elective	125s
247	Geol. and Exploration of Lake Superior Region	3	..	Elective	125s

1w,2s. General Geology. A synoptical treatment of materials of the earth, and of geologic processes. Physiographic, dynamic, structural, and historical geology. Mr. Thiel.

19s. Elements of Paleontology. An introduction to the study of fossil organisms. Lectures supplemented by field excursions. Mr. Stauffer.

23f,24w,25s. Elements of Mineralogy. The crystal systems; morphological, physical, chemical characters of minerals; occurrence, genesis, and uses of minerals; classifications and description of common minerals; rock minerals, and common rocks. Determinative work in the laboratory, blowpipe analysis, sight identification. Mr. Broderick, Mr. Gruner, Mr. Werner.

61f. Blowpipe Analysis. The determination of minerals by systematic blowpipe analysis. Mr. Broderick, Mr. Gruner.

65f. Crystallography. Projection and geometric relations of crystal planes; crystal nomenclature; the relation of special properties to morphology. A study of crystal models, crystal-drawing, identification of minerals from crystal measurements, and mathematical calculation. Mr. Broderick, Mr. Gruner.

73f. Economic Geology. Study of non-metallic minerals of economic value, and discussions of geologic guides to prospecting for these deposits. Mr. Schwartz.

80w. Advanced Historical Geology. The sequence of events in geologic history, of interest to the advanced student in mining. Mr. Stauffer, Mr. Thiel.

85s. Field Work. About two weeks in June are spent in geologic mapping of selected areas in the iron district of Minnesota. Involves preparation of geologic maps and written reports. Mr. Gruner, Mr. Schwartz.

91f-92w-93s. Paleontology. Index fossils of North America. A study of fossil forms with special reference to those of geologic importance; faunas and their correlation. Mr. Stauffer.

101f. Principles of Stratigraphy. Origin and structure of sedimentary deposits; the interpretation of these in relation to paleography; field work in connection with Cambrian and Ordovician problems. Mr. Allison.

105f. Rock Study. The occurrence and genesis of igneous, sedimentary, and metamorphic rocks; their mineral and chemical composition; their structure, texture, and alteration. The classification and methods of identification and description of rocks. Mr. Grout, Mr. Broderick, Mr. Thiel.

106w. Petrography. The identification and study of minerals and rocks by optical methods; the study of igneous rocks, crystalline schists, and metamorphic rocks. The origin and classification of rocks. Mr. Grout, Mr. Broderick, Mr. Gruner, Mr. Thiel.

111f. Ore Deposits. The nature, distribution, and genesis of ore deposits of the United States; relations of ore deposits to geologic structure; the deformation and superficial alteration of ore deposits. Mr. Emmons.

112w. Geology of Petroleum. The nature, origin, and accumulation of petroleum; discussion of the various oil fields of the world. Mr. Emmons.

113s. Problems in Ore Deposits. Field excursions, map work, lectures on field and laboratory methods. Mr. Emmons.

124w,125s. Structural and Metamorphic Geology. The conditions, processes, and results of metamorphism; structural features resulting from deformation under varying conditions of load. Mr. Schwartz.

131f,132w,133s. Advanced Petrology. Advanced optical methods. Criteria for rapid identification of minerals and rocks. The uses of schedules and tables. Standard rock types. Regional and genetic studies. Petrographic reports. Mr. Grout.

137w. Testing Economic Minerals. Methods of determining quality of mineral deposits, described and illustrated by laboratory tests of coal, clay, oil, building stone, and metallic ores. Mr. Grout.

140w,141s. Applied Petrography. Determination of ores and gangue minerals. Microscopic studies of paragenesis of ores and other mineral associations. Practical problems in mining and geology settled by microscopic and optical examinations. Mr. Grout.

144w,145s. Construction and Interpretation of Geologic Maps. Methods of geologic examination; problems in construction and interpretation of geologic maps and sections. Mr. Allison.

150s. Field Geology. Detailed, systematic work conforming with standards of official surveys. Preparation of geologic maps, structure sections, reports; paragenesis of ores and their relations to geologic structures. Field for 1922, Black Hills, South Dakota. Reports to be written week before college opens in fall. Mr. Emmons, Mr. Schwartz.

151f,152w,153s. Advanced General Geology. Geologic processes and their results; development of the North American continent. Mr. Stauffer.

166w,167s. Mineralography. Methods of studying opaque minerals and the application of the methods to problems in ore genesis and history. Mr. Broderick, Mr. Schwartz.

246. Pre-Cambrian Geology. The problems of pre-Cambrian correlation and structure; the pre-Cambrian stratigraphy of North America. (Given in alternate years.)

247. Geology and Exploration of Lake Superior Region. The geology of the Lake Superior iron districts. Methods used in the exploration of iron ore; interpretation of drill cores; cartographic expressions of drill data; models of drilled areas. Principles of magnetic surveying.

GERMAN

Professor Carl Schlenker; Assistant Professors James Davies, Samuel Kroesch.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
24f,25w,26s*	Beginning	3	Jr.E.M.(Geol.)	....
27f	Narrative Prose.....	4	Elective	26 or 2 yrs. prep.
28w,29s*	Advanced Chemical.....	3	Elective	27

* All quarters must be completed before credit is given in any one quarter.

24f,25w,26s. Beginning for Miners. Pronunciation, grammar, conversation; selected readings in easy prose. Mr. Davies.

27f. Narrative Prose. Reading, grammar review. Mr. Kroesch.

28w,29s. Chemical German. Selections from more difficult works on chemistry. Mr. Schlenker.

METALLURGY

Professors William R. Appleby, Peter Christianson, Levi B. Pease; Associate Professor Oscar E. Harder; Instructors Ralph L. Dowdell, Edwin H. Kersten, Clayton M. Reasoner, Elwyn L. Smith.

COURSES

No.	Title	Lec. hrs.	Lab. hrs.	Required of	Prerequisite course
1w	Assaying	4	..	All fr.	Chem. 14f, Geol. 23f
2w	Assaying Lab.	..	8	All fr.	Chem. 14f, Geol. 23f
3f	General Metallurgy	3	..	All soph.	1w, 2w, Chem. 16s
4w	Metallurgy of Pig Iron	3	..	All soph.	3f
5s	Met. Wrought Iron and Steel	3	..	All soph.	4w
6f	Ore-Testing	2	..	Sr.E.M.&Met.E.	107s
7f	Ore-Testing Lab.	..	8	Sr.E.M.&Met.E.	107s
8w	Spec. Prob. in Ore-Test.	..	4	Sr.E.M.&Met.E.	107s
9s	Spec. Prob. in Ore-Test.	..	8	Sr.E.M.&Met.E.	107s
10w	Advanced Metallurgy	4	6	Sr.Met.E.	107s
11s	Advanced Metallurgy	4	6	Sr.Met.E.	107s
12f	Ore-Dressing	3	..	All jr.	Phys.43s,Geol.25s
13w	Ore-Dressing	3	..	All jr.	Met.12f
14f	Ore-Dressing Lab.	..	4	Jr.Met.E.	Phys.43s,Geol.25s
15w	Ore-Dressing Lab.	..	4	Jr.Met.E.	Met.12f,14f
16s	Ore-Dressing Lab.	..	6	Jr.Met.E.	Met.13w,15w
17s	Ore-Dressing Lab.	..	6	Jr.E.M.&E.M.(Geol.)	Met.13w
18f	Thesis in Metallurgy	..	8	Sr.Met.E.	Satisfactory completion of jr. year
19w	Thesis in Metallurgy	..	18	Sr.Met.E.	18f
20s	Thesis and Specifications	..	18	Sr.Met.E.	19w
21s	Field Work in Met.	..	**	Jr.Met.E.	Same as 18f
22f	Metallurgy	3	..	M.E.&Chem.Elective	Chem.8s or equiv.
23w	Metallurgy	3	..	E.E.&Chem.Elective	Chem.8s or equiv.
105f	Met. of Base Metals.	4	..	Jr.E.M.&Met.E.	3f
106w	Met. of Base Metals.	4	..	Jr.E.M.&Met.E.	105f
107s	Met. of Precious Metals.	4	..	Jr.E.M.&Met.E.	106w
108f	Electrometallurgy	3	..	Sr.Met.E.	107s
150f	Mphy. for Elec. Eng.	2	3	Elective	....
151w	Adv. Mphy. for Elec. Eng.	2	3	Elective	150f
153f	Mphy., Long Course.	3	4	Jr.Met.E.	Chem.28w,Phys.43s
154w	Mphy., Long Course.	3	4	Jr.Met.E.	153f
155s	Mphy., Long Course.	3	4	Jr.Met.E.	154w
156f	Mphy. for Mech. Eng.	2	3	Elective	....
157w	Adv. Mphy. for Mech. Eng.	2	3	Elective	156f

** Ten days.

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
159s	Dental Metallography	2	..	Elective	Chem. 21-22
160f	Mphy. for Chemists	2	2	Elective	Chem. 20
161w	Adv. Mphy. for Chemists	2	2	Elective	160f
162s	Adv. Mphy. for Chemists	2	2	Elective	160f
163f	Adv. Metallography	To be ar.		Elective	151, 155, 157 or equiv.
164w	Adv. Metallography	To be ar.		Elective	.....
165s	Adv. Metallography	To be ar.		Elective	.....
201f	Adv. Mphy. for Gr. Students	To be ar.		Elective	.....
202w	Adv. Mphy. for Gr. Students	To be ar.		Elective	.....
203s	Adv. Mphy. for Gr. Students	To be ar.		Elective	.....

1w. ASSAYING. The determination of values of ores, metallurgical products by the fire method. Lectures and recitations. MR. APPLEBY, MR. CHRISTIANSON.

2w. ASSAY LABORATORY. Practical determination of gold, silver, lead, and tin by the fire method. MR. CHRISTIANSON, MR. PEASE, MR. KERSTEN, MR. SMITH.

3f. GENERAL METALLURGY. Combustion, fuels, refractory materials, furnaces and fluxes. Lectures and recitations. MR. CHRISTIANSON.

4w. METALLURGY OF PIG IRON. General principles of iron blast furnace practice. Construction of furnace, handling of stock, and products, principles of regulation. Lectures and recitations. MR. CHRISTIANSON.

5s. METALLURGY OF WROUGHT IRON AND STEEL. General principles involved in the production of wrought iron and steel. Lectures and recitations. MR. CHRISTIANSON.

6f. ORE-TESTING. General principles involved in determining the best method of extraction, including amalgamation, concentration, cyanidation, roasting, etc. Lectures and recitations. MR. CHRISTIANSON.

7f. ORE-TESTING LABORATORY. Practical determination of extraction and distribution of values in mill and metallurgical products. Methods of calculation. MR. CHRISTIANSON and assistants.

8w. SPECIAL PROBLEMS IN ORE-TESTING. Continuation of Course 7f. Practical determinations for regulating metallurgical operations. MR. PEASE.

9s. SPECIAL PROBLEMS IN ORE-TESTING. Continuation of Course 8w. MR. PEASE.

10w. ADVANCED METALLURGY. Pyrometry, calorimetry, and metallurgical calculations to determine heat balance and heat distribution. Lectures and laboratory work. MR. CHRISTIANSON.

11s. ADVANCED METALLURGY. Design of furnaces, conferences, and laboratory work. MR. CHRISTIANSON.

12f. Ore-Dressing. Crushing, sizing, classification, and concentration of ores. Lectures and recitations. Mr. Smith.

13w. Ore-Dressing. Continuation of Course 12f. Mr. Smith.

14f. Ore-Dressing Laboratory. Practical examination of ores and the use of ore-dressing machinery. Mr. Smith.

15w. Ore-Dressing Laboratory. Practical problems in ore-dressing. Mr. Smith.

16s. Ore-Dressing Laboratory. Continuation of Course 15w. Mr. Smith.

17s. Ore-Dressing Laboratory. Short course in the laboratory use of ore-dressing machinery. Mr. Smith.

18f. Thesis in Metallurgy. Conferences to select suitable problem together with preliminary laboratory work on problem selected. Mr. Christianson, Mr. Pease.

19w. Thesis in Metallurgy. Continuation of Course 18f. Mr. Christianson, Mr. Pease.

20s. Thesis and Specifications. Completion of thesis including specifications covering installation of a plant. Mr. Christianson, Mr. Pease.

21s. Field Work in Metallurgy. Study of metallurgical operations at smelters and mills. Detail reports are required covering plants visited. Mr. Christianson, Mr. Pease.

22f. Metallurgy of Base Metals. Short course for mechanical engineers. Special consideration is given to the mechanical appliances. Lectures and recitations. Mr. Christianson, Mr. Pease.

23w. Metallurgy of Base Metals. Short course for electrical engineers. Special consideration is given to electrical appliances. Lectures and recitations. Mr. Christianson, Mr. Pease.

105f. Metallurgy of Base Metals. Lead, copper, zinc, and mercury. Consideration of smelting methods and principles involved in refining. Lectures and recitations. Mr. Pease.

106w. Metallurgy of Base Metals. Continuation of Course 105f. Mr. Pease.

107s. Metallurgy of the Precious Metals. Principles involved and methods used in the extraction of gold, silver, and other precious metals. Lectures and recitations. Mr. Pease.

108f. Electrometallurgy. Application of electricity to production of heat for smelting ores and refining metals. Costs of fuel and electricity for heating, relative efficiencies of electric and fuel furnaces. Construction of high temperature furnaces and commercial plants. Mr. Christianson.

150f. Metallography for Electrical Engineers. Principles of metallography, including pyrometry, thermal analysis, constitution diagrams, microscopic and photomicrographic technique; study of typical alloys with special reference to electrical resistance, conductivity, magnets, etc. Laboratory work and demonstrations. Mr. Harder, Mr. Dowdell, Mr. Reasoner.

151w. Advanced Metallography for Electrical Engineers. Continuation of 150. Study of iron and steel, alloy steels, metals and alloys used in electrical engineering practice. Special problems for outside reading and for research. Laboratory work. Mr. Harder, Mr. Dowdell, Mr. Reasoner.

153f,154w,155s. Metallography. (Long course for metallurgical engineers.) Theory of metallic alloys. Metallographic technique. Properties of metals and alloys. Metallography of iron and steel and commercial alloys. Technical metallurgy. Laboratory work. Mr. Harder, Mr. Dowdell, Mr. Reasoner.

156f. Metallography for Mechanical Engineers. Principles of metallography, including pyrometry, thermal analysis, constitution diagrams, microscopic annd photomicrographic technique; metallography and heat treatment of iron and steel. Laboratory work. Mr. Harder, Mr. Dowdell, Mr. Reasoner.

157w. Advanced Metallography for Mechanical Engineers. Continuation of 156f. Metallography of alloy steels, tool steels, high speed tool steels, and important non-ferrous alloys; metallography applied to engineering practice and specifications. Outside reading and special reports. Laboratory work. Mr. Harder, Mr. Dowdell, Mr. Reasoner.

159s. Dental Metallography. Study of the dental alloys from the standpoint of metallography. Lectures, recitations, and demonstrations, taking up the most important metals and alloys, with special reference to those used in dentistry. Mr. Harder, Mr. Dowdell, Mr. Reasoner.

160f. Metallography for Chemical Students. Metallography, including constitution diagrams, preparation and standardization of thermocouples, preparation and thermal analysis of alloys, their microscopic examination and making photomicrographs; typical alloy systems such as iron-carbon (steel and cast iron); some non-ferrous alloys. Laboratory work. Mr. Harder, Mr. Dowdell.

161w. Advanced Metallography for Chemical Students. Metallography and heat treatment of iron and steel, including alloy steels, commercial uses of various steels, and engineering specifications. Laboratory work. Mr. Harder, Mr. Dowdell.

162s. Advanced Metallography for Chemical Students. Metallography of the non-ferrous metals with a study of the constitution diagrams, properties, and uses of important commercial alloys. Laboratory work. Mr. Harder, Mr. Dowdell.

163f,164w,165s. Advanced Metallography. Technical and scientific research. The study of steel rails, automobile and locomotive parts, tool steels, etc. Special problems in metallography with outside reading. Seminar work on the recent advances in metallography. Mr. Harder, Mr. Dowdell.

201f,202w,203s. Advanced Metallography for Graduate Students. Intended primarily for research work. Mr. Harder.

MILITARY SCIENCE AND TACTICS

Professor Girard Sturtevant, Colonel, Infantry; Assistant Professors James E. Ware, Lieutenant Colonel, Retired; Henry H. Rutherford, Lieutenant Colonel, Medical Corps; Laurence T. Walker, Major, Coast Artillery Corps; Lee R. Watrous, Jr., Major, Coast Artillery Corps; Frederick R. Wunderlich, Major, Dental Corps; Edward G. Sherburne, Major, Infantry; James E. Watson, Captain, Signal Corps; Newton W. Speece, Captain, Infantry; Andrew C. Tychsen, Captain, Infantry; Russell C. Throckmorton, Captain, Infantry; Leo J. Farrell, Captain, Infantry; Hal M. Rose, Captain, Cavalry; Instructors Joseph Havlicek, Regimental Commissary Sergeant, Retired; Carl Jensen, Regimental Supply Sergeant, Retired; John McWilliams, 1st Sergeant, Retired; Henry Dahl, 1st Sergeant, Retired; Harry E. Strider, Technical Sergeant, Signal Corps; Alfred Brandt, Technical Sergeant, Infantry; Aubrey Dunkum, Staff Sergeant, Coast Artillery Corps; Clarence E. Lange, Sergeant, Field Artillery; Joe Weir, Sergeant, Infantry; Edmund T. McCann, Sergeant, Infantry; Henry W. Brown, Sergeant, Coast Artillery Corps; Earl J. Blonschine, Private, 1st Class, Coast Artillery Corps.

COURSES

No.	Title	Hrs.	Required of	Prereq. courses
1	First-year Basic Course R.O.T.C.....	3	†All fr.	None
2a	Second-year Basic Course R.O.T.C., Infantry	3	*Soph.	1
2b	Second-year Basic Course R.O.T.C. Coast Artillery	3	Soph	1
2c	Second-year Basic Course R.O.T.C., Signal Corps	3	Soph	1

* Work in military science and tactics for sophomores will open on Friday, September 15, at 8:30 a.m., and continue for ten days. Satisfactory completion of Course 2a, 2b, or 2c at that time is required of all sophomores. This course applies only to sophomores who are required to leave the following May 1 for field work.

† Must be legally eligible for enrolment in Reserve Officers' Training Corps.

MINE PLANT AND MECHANICS

Professor Elting H. Comstock; Assistant Professors Anders J. Carlson, James C. Sanderson.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	Algebra and Solid Geometry	6	..	B fr.	..
2f	Algebra	6	..	A fr.	..
3s	Algebra	4	..	B fr.	1f
4w	Trigonometry	6	..	All fr.	..
5s	Analytical Geometry	6	..	All fr.	4w
6f	Calculus	4	..	All soph.	5s
7w	Calculus	3	..	All soph.	6f
8s	Calculus	6	..	All soph.	7w
9f	Mechanics	5	..	Jr.E.M.&Met.E.	8s
10w	Mechanics of Materials	5	..	Jr.E.M.&Met.E.	9f
11s	Mechanics of Materials	5	..	Jr.E.M.&Met.E.	10w
12f	Mine Plant	6	..	Jr.E.M.&Met.E.	8s
13w	Mine Plant	6	..	Jr.E.M.	12f
14s	Mine Plant	6	..	Jr.E.M.	13w
15w	Metallurgical Plant	3	..	Jr.Met.E.	12f
16s	Metallurgical Plant	3	..	Jr.Met.E.	15w
17f	Hydraulics and Water Power	5	2	Sr.E.M.&.Met.E.	11s
18f	Engineering Construction	..	8	Sr.E.M.	11s
19w	Mine Plant Design	..	9	Sr.E.M.	18f
20s	Mine Plant Design	..	12	Sr.E.M.	19w

1f. Algebra and Solid Geometry. Equations, involution and evolution, theory of exponents, surds, quadratic equation, theory of logarithms, determinants. Demonstrations of most important theorems of solid geometry. Volumes, approximate volumes, prismoidal formula, etc. Mr. Sanderson.

2f. Algebra. Functions, functional notation, factor and remainder theorems, factors and values of functions, development of functions, progressions, series, theory of equations, permutations and combinations, theory of logarithms, determinants. Mr. Comstock, Mr. Sanderson.

3s. Algebra. Continuation of Course 1. Functions, functional notation, factor and remainder theorems, factors and values of functions, development of functions, progressions, series, theory of equations, permutations and combinations. Mr. Sanderson.

4w. Trigonometry. Trigonometric ratios, right triangles, definitions of trigonometric functions, analytic relations, trigonometric equations, etc., solution of spherical triangles. Mr. Comstock, Mr. Sanderson.

5s. Analytical Geometry. Systems of coördinates, loci, equations, properties of straight line, transformation of coördinates, equations and properties of conics, equations of second degree, higher plane curves, space coördinates, point, plane, quadric surfaces, etc., empirical equations, graphic algebra. Mr. Sanderson.

6f,7w,8s. CALCULUS. Differentiation, elementary forms, geometric applications, rates, successive differentiation, maxima and minima, expansion of functions, intermediate forms, partial derivatives, change of variable, elementary integration, undetermined coefficients, rationalization, formulas of reduction, some differential equations of mechanics. MR. SANDERSON.

9f. MECHANICS. Composition and resolution of forces, laws of equilibrium, practical applications, rectilinear motion, circular motion, curvilinear motion in general, dynamics of rigid bodies, impact, work, and energy. MR. CARLSON.

10w,11s. MECHANICS OF MATERIALS. Mechanical and elastic properties of materials of construction; beams, columns, shafts, hollow cylinders and spheres, rollers, plates; theory of internal stress; reinforced concrete. MR. CARLSON.

12f,13w,14s. MINE PLANT. Discussion of the machinery and appurtenances employed in the equipment of mines. Air compression, rock drills, mechanical features of hoisting, pumping, ventilation, underground transportation. Electricity applied to mining. MR. COMSTOCK.

15w,16s. METALLURGICAL PLANT. Power, air, and water supply for metallurgical plants. MR. COMSTOCK.

17f. HYDRAULICS AND WATER POWER. Laws of the equilibrium, pressure and flow of liquids, hydrographs and mass diagrams, estimate of power to be developed at a power site, design of dams and hydroelectric plants, theory of water wheels and turbines, speed control, power house equipment, transmission. MR. CARLSON.

18f. ENGINEERING CONSTRUCTION. Theory of structures, loading, analytic and graphic resolution of stresses in framed structures, stresses in mining structures,, design of mining structures. MR. CARLSON, MR. HEILIG.

19w,20s. MINE PLANT DESIGN. A study of power possibilities, costs, etc., and designs of a power plant, surface equipment, and structures for a mine. MR. COMSTOCK, MR. HEILIG.

MINING

Associate Professor WALTER H. PARKER; Instructor LOUIS S. HEILIG.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prerequisite courses
21s	Introductory Mining....	4	..	Jr.E.M.&E.M.(Geol.)	31f
30f	First Aid.....	..	*	Jr.E.M.&E.M.(Geol.)	21s
31f	Exploration	5	..	All soph.	..
32w	Tunneling	5	..	All jr.	..

33s	Mining Methods.....	5	..	Jr.E.M.&E.M.(Geol.)	32w
34s	Practical Mining.....	..	2 wks.	Jr.E.M.&Met.E.	Satisfactory completion of junior yr.
40f	Mine Rescue	..	*	All sr.	..
41f	Mining Methods.....	5	..	Sr.E.M.&E.M.(Geol.)	33s
42w	Mine Management.....	5	..	Sr.E.M.&E.M.(Geol.)	41f
43s	Mine Administration....	5	..	Sr.E.M.&Met.E.	42w
44f	Thesis	..	2	Sr.E.M.	33s
45w	Thesis	..	12	Sr.E.M.	44f
46s	Thesis	..	12	Sr.E.M.	45w

* 15 hours a week.

21s. INTRODUCTORY MINING. Introductory mining course, preparatory to sophomore field trip. MR. HEILIG.

30f. FIRST AID. Course in first aid to the injured, given by the staff of the United States Bureau of Mines car.

31f. EXPLORATION. Occurrence of ore bodies, prospecting, exploration, boring, explosives, drilling, and blasting. MR. PARKER.

32w. TUNNELING. Tunneling, drifting, shaft-sinking, raising, and mining methods. MR. PARKER.

33s. MINING METHODS. Underground mining methods and support of underground excavations. MR. PARKER.

34s. PRACTICAL MINING. Study of mining operations. Mine plant and mining work in one or more mining camps. MR. PARKER, MR. COMSTOCK.

40f. MINE RESCUE. Course in mine rescue, given by the staff of the United States Bureau of Mines car.

41f. MINING METHODS. Coal mining, open-pit work, quarrying, placer mining, hydraulic mining, and dredging. MR. PARKER.

42w. MINE MANAGEMENT. Mine drainage, mine ventilation, mine transportation, mine sanitation, mine hygiene, cost accounting, and mine examination. MR. PARKER.

43s. MINE ADMINISTRATION. Course in mining law, mine management, and economics of mining. MR. PARKER.

44f. THESIS. Preparatory work on the mining thesis. MR. PARKER, MR. HEILIG.

45w. THESIS. Preparation of an original thesis on some mining project, covering the exploration and development of a mining property. MR. PARKER, MR. HEILIG.

46s. THESIS. Completion of thesis project. MR. PARKER, MR. HEILIG.

MINING ENGINEERING

Professor Edwin M. Lambert.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
1f	Mine-Surveying	3	..	All soph.	Math. 4w
2w	Mine-Surveying	3	..	All soph.	1f
3s	Mine-Surveying	3	4	All soph.	2w
4s	Field Work	..	7 wks.	All soph.	3s
5w	Mine-Mapping	..	6	All jr.	4s
6s	Mine-Mapping	..	6	Jr.E.M.&Met.E.	5w

1f-2w-3s. Mine-Surveying. Theory and problems in mine-surveying including land subdivision, stadia measurements, triangulation, railroad curves and cross sections, computation of areas by coördinates; differential leveling, topographic map-reading, solar observations, shaft plumbing, underground traversing and leveling. Mr. Lambert.

4s. Field Work. Practice in general plane surveying during the month of May. Practice in underground surveying during the first three weeks of June. This work is given on the iron ranges of Minnesota. Mr. Lambert, Mr. Carlson, Mr. Heilig.

5w-6s. Mine-Mapping. Mine-mapping in accordance with prevalent practice in mining districts. Ore and stripping estimates and mine maps based on Mesabi Range practice. Mr. Heilig.

PHYSICS

Professors Henry A. Erikson, Anthony Zeleny; Assistant Professor Louallen F. Miller.

COURSES

No.	Title	Lec. or rec. hrs.	Lab. hrs.	Required of	Prereq. courses
3f	Elements of Mechanics	3	..	All soph.	Math. 5s
4f	Mechanics Laboratory	..	2	All soph.	With 3f
23w	Heat	3	..	All soph.	3f
24w	Heat Laboratory	..	2	All. soph.	4f and with 23w
43s	Magnetism and Electricity	3	..	All soph.	3f
44s	Magnetism and Electricity Lab.	..	2	All soph.	4f and with 43s

3f. Elements of Mechanics and Sound. Mechanics of solids, fluids, wave motion, and sound. A study of the simpler fundamental principles. First part of a general Course 3, 23, 33, 43. Course 4 should be taken in conjunction with this course. Mr. Erikson, Mr. Miller.

4f. Elements of Mechanics and Sound Laboratory. Measurements in the mechanics of solids, fluids, wave motion, and sound; the laboratory part supplementing Course 3. One two-hour session in the laboratory a week. Mr. Erikson, Mr. Miller.

23w. Heat. A study of the principles underlying heat phenomena. Course 24 should be taken in conjunction with this course. Mr. Miller.

24w. Heat Laboratory. The laboratory part supplementing Course 23. One two-hour session in the laboratory a week. Mr. Miller.

43s. Magnetism and Electricity. A study of the principles underlying magnetic and electric phenomena. Course 44 should be taken in conjunction with this course. Mr. Zeleny, Mr. Miller.

44s. Electrical Laboratory. The laboratory part supplementing Course 43. One two-hour session in the laboratory a week. Mr. Zeleny, Mr. Miller.

ROMANCE LANGUAGES

Professors Everett W. Olmsted, Irville C. LeCompte, Colbert Searles; Associate Professor Ruth S. Phelps.

COURSES

No.	Title	Rec. hrs.	Required of	Prereq. courses
1-2*	Beginning French	5	Jr.E.M.(Geol.)	....
3-4	Intermediate French	5	Elective	1-2
21-22-23*	Survey French Lit.	3	Elective	3-4
1-2*	Beginning Spanish	5	Jr.E.M.(Geol.)	....
3-4	Intermediate Spanish	5	Elective	1-2
65-66-67*	Spanish Literature	3	Elective	3-4

* All quarters must be completed before credit is given in any one quarter.
Note: Beginning and intermediate courses are offered every quarter.

1-2. Beginning French.

3-4. Intermediate French.

21-22-23. General Survey of French Literature. Outline of French literature from 1600 to the present. Reading of representative texts.

1-2. Beginning Spanish.

3-4. Intermediate Spanish.

65-66-67. Spanish Literature. Outline of Spanish literature from 1500 to the present. Reading of representative texts.